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New Ceramic Fiber

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Product Applications of Vinyl Plastisols and Plastigels

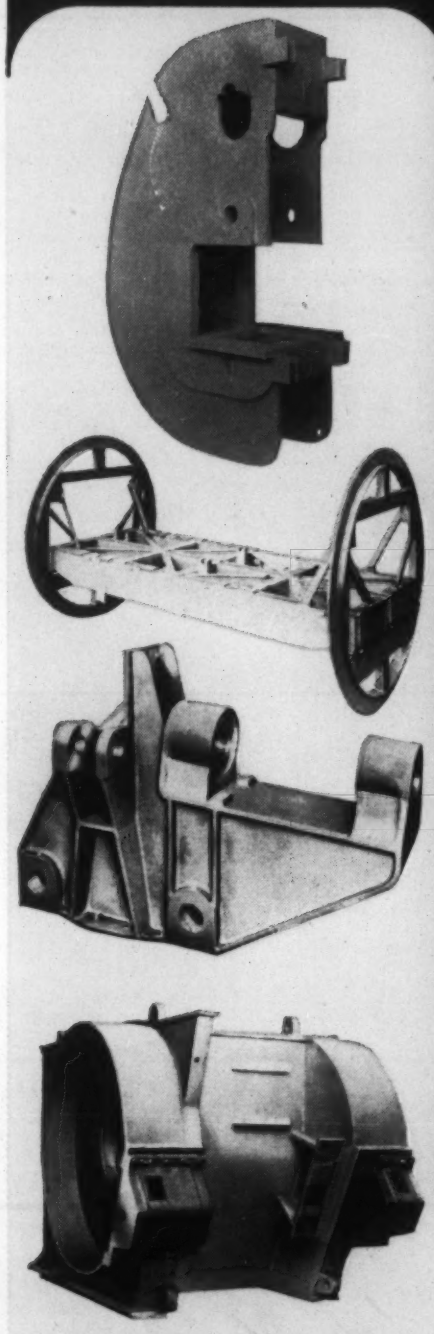
Indium Alloys for Commercial Uses

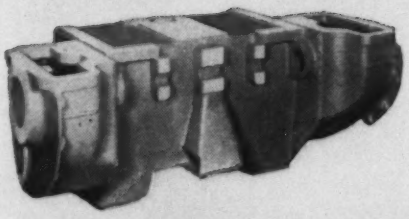
Flash Welding Titanium Alloys

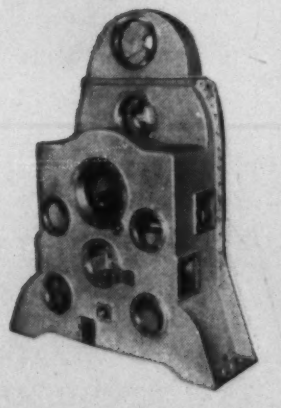
Nondestructive Testing of Ceramic Parts

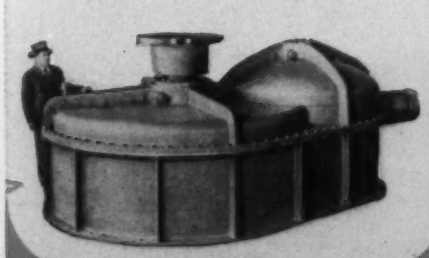
CARBON AND LOW ALLOY STEEL CASTINGS
—*Materials & Methods Manual No. 86*

THE MAGAZINE OF
MATERIALS ENGINEERING
DEVOTED TO THE MATERIALS PROBLEMS OF PRODUCT DESIGN AND MANUFACTURE









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The Materials Outlook

Finely divided nylon powder can be processed by cold pressing and sintering, similar to powder metallurgy techniques. Powder is processed below the melting point, and there is less tendency to internal strain. Dimensional stability in parts made by this method is greater than in injection molded products. Uniform blends with fillers can be made to reduce thermal and hygroscopic expansion or to obtain special electrical properties. Bearings, gears, cam rollers and valve seats are possible applications.

New silicone rubber has tensile and elongation properties about double those of currently offered silicone rubbers. This material is competitive, on a property basis, with natural and synthetic rubbers. Tensile strengths range from 1000 to 2000 psi, elongations from 200 to 800%. Temperature service range and resistance to compressive set, ozone, oils, lubricants and hydraulic fluids are as good as in presently available silicone rubbers. Applications are expected in unsupported films, O-rings coated fabrics, gaskets, wire coatings and insulation.

Vinyl plastisol coatings are being used more and more on plating equipment. Besides plating racks, coatings are used on ventilating ducts, tanks, conveyor hooks, degreasing and dipping baskets, drainboards, tank grids, plating barrels, flexible cable, solution agitators and submerged piping. Chemical resistance, resiliency and durability are the selling points.

Metals production expansion plans show changing materials patterns in the next few years. The expansion over 1950 production for 1955 include a 10% increase for lead, 18% for zinc, 20% for steel, 23% for nickel, 44% for cobalt, 50% for tungsten, 51% for molybdenum and 100% for aluminum.

MIT has a numerically controlled milling machine. Instructions are fed in on punched tape. The machine does tasks in minutes which take hours by current practice. Instructions given the machine may be of unlimited precision. Once the tape is properly punched, it gives a compact, permanent record that can be used at any time for duplicate parts. Such a tape may be a big saving in the aircraft industry, where one machine mills a variety of parts on a staggered schedule.

Much of the post war interest in aluminum can be explained by prices. Between 1939 and May 1952, aluminum went down 5% in price. Steel increased 78%, copper 118%, lead 197%, pig iron 147% and zinc 280%.

Recently developed process reproduces photograph, painting or drawing on nonporous surface. A gelatized surface sensitive to ultra-violet light

(Continued on page 4)

The Materials Outlook *(continued)*

is used. This is claimed to be less expensive than the silk screen process. Printed electrical circuits on vitreous enamel are being studied for the process.

An induction heating unit is built into a new hot nut machine. Bars are continuous heated for hot forming in the machine. The first model is now ready for testing.

Research is progressing on rotating bands for shells. Iron powder now has a new technique as a competitor. The new method is to build up a band of soft iron around the shell by conventional welding. This soft iron, so far, compares favorably with iron powder in firing tests.

Special equipment is used to arc weld stainless steel, Ni-Span C and phosphorus bronze diaphragms from 0.0015 to 0.005 in. thick. The diaphragms are used for pressure transducers, pressure elements and instrument seals.

Abrasive belts can produce tapered aircraft skins cheaper, faster, better and with less capital expense than other methods. A wide belt with a rubber-faced contact roll cuts up to 0.1 in. across a 72-in. wide aluminum sheet. Tolerances of ± 0.005 in. can be held. The aluminum can be polished on the same machine.

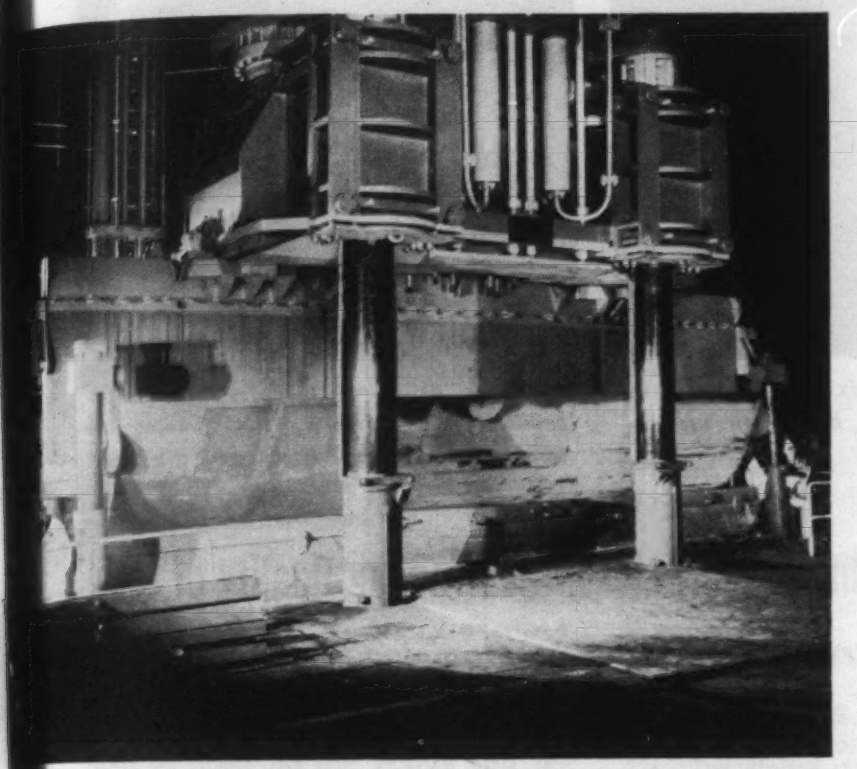
Fast method for purifying zirconium has been developed by the National Bureau of Standards. Concentrated sulfuric acid is poured into zirconium sulfate or chloride solution. The resulting precipitate is dissolved in water and reprecipitated several times. This gives high purity zirconium sulfate.

New telephone and telegraph cable developed by the Army Signal Corps lasts longer, costs less and carries more traffic. The new cable is a third lighter than the old type. The insulation is made of plastics instead of rubber. Stainless steel replaces regular steel in the cable.

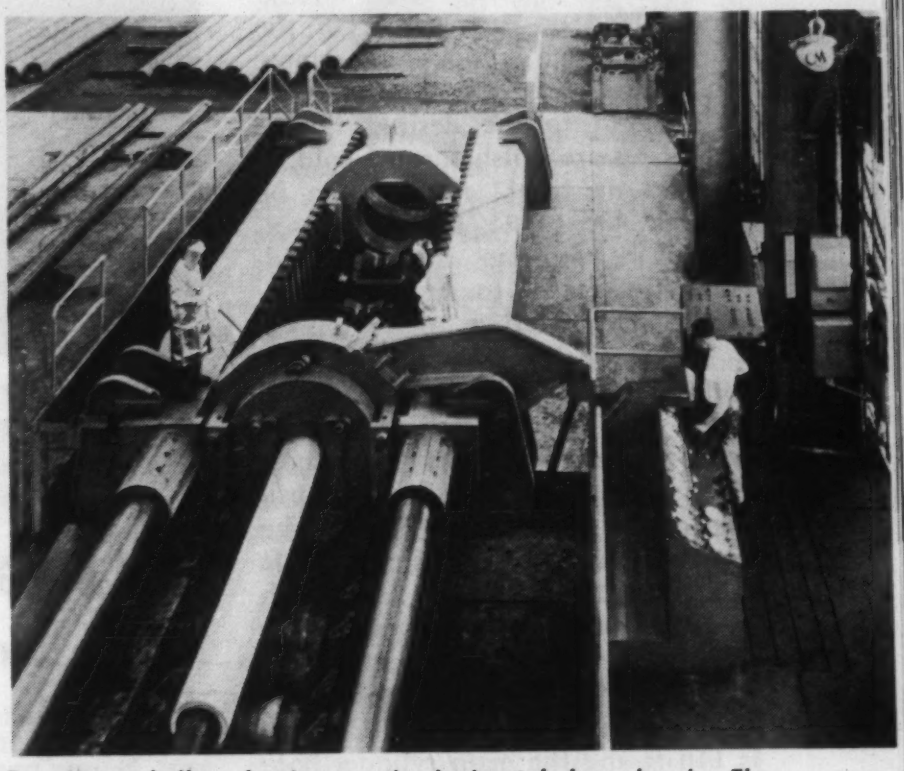
Soft soldering of sheet aluminum and magnesium directly with 50-50 tin-lead, using no flux and no special cleaning or abrading preparation, is reported. Commercial model tool which can be engineered for specific applications is being developed.

Gold and silver are being plated to precise thickness and adherence specifications. The base metals include beryllium copper, tellurium bronze, telnic bronze, leaded brasses and carbon and alloy steels. Silver is used for excellent electrical conductivity, resistance to corrosion and for its lubricating and anti-galling properties. Gold is chosen for corrosion resistance and because it is a fair electrical conductor. Tiny electrical connectors and stainless steel bolts and studs are typical plated parts.

See page 6 for "Materials Control Orders"



The heaviest plate ever rolled is formed into a boiler drum section at the Barberton, Ohio, plant of the Babcock & Wilcox Co.



Drawing a hollow forging on the horizontal draw bench. The forging is forced by the mandrel through a series of ring dies.

Huge Hollow Forgings Formed by New Press and Draw Bench

Forgings Up to 35-In. Dia and Largest Plate Ever Rolled Formed in New Equipment

The heaviest plate ever rolled in this country and huge hollow forgings are being formed on a new vertical press and horizontal draw bench recently built and installed by the Babcock & Wilcox Co. at their Barberton, Ohio, plant.

The press and draw bench will produce a rough hollow forging up to 35 in. in outside dia with 4½-in. walls. It was formerly necessary to make such pieces by welding rolled steel plates or by boring out a solid forging. The hollow forgings will be used mainly for boiler parts and connecting steam lines operating at high pressures and temperatures.

In forming these hollow forgings, a heated ingot is first pierced in the vertical press. This puts a lengthwise opening in the ingot. The hollow ingot, or bloom, is then taken to the horizontal draw bench. It is fitted over a mandrel to hold inside dimensions and forced through a series of ring dies by the head of the mandrel, reducing the outside diameter and increasing its length to proper size. The result is a seamless, hollow forging of predetermined inside and outside diameter.

Ingots or billets of varying cross-sections, such as gothics, hexagons, octagons, rounds, or squares with round corners, can be successfully shaped on the equipment. Various shapes of mandrels and dies, other than round, can be used on the horizontal draw bench to produce many different cross-sections, such as squares, rectangular shapes, D shapes or ovals.

The new equipment will produce seamless hollow forgings from a minimum of 8-in. inside dia and ¾-in. wall thickness, in lengths up to 22 ft. The maximum weight of the cropped ingot which the equipment can handle—26,000 lb—controls the maximum final size of the forging, which may be 14 to 15 ft in length for heavy wall thickness and large diameters, and up to 22 ft in length for lighter wall forgings.

As the special tooling for this process can be changed quickly, it is possible to produce one or two lengths of a particular size or of a specially desired specification of steel at very little unit cost per forging for the change-over. Both alloy and carbon steels can be successfully used in the process.

When the press is used to form drum plates to a predetermined radius, the piercing apparatus is moved out from between the press columns. The horizontal hot plate is moved under the press, below a heavy vertical plate-like structure attached to the moving part of the press. This moves down, creasing the hot plate longitudinally and conforming it to a female circular die of predeter-

(Continued on page 10)

mined radius on which the plate rests. The plate itself is manipulated back and forth on the die by four hydraulic units which hook into U bars welded on each corner of the plate. The plate is moved by remote control and creased at close intervals to conform to the desired radius. The plates are finish formed cold.

Plates up to 42 ft long can be handled. Up to 2¾-in. thicknesses, the entire forming is done cold. Heavier plates are rough formed hot, then finished cold.

The vertical hydraulic press was built almost entirely by the B & W Boiler Div. Normal capacity is 6500 tons, intensified capacity 8500 tons. The operating pressure is 3000 psi. The operating stroke is 9½ ft. The four supporting columns are 52 ft high and 26 in. in dia and each weighs 41 tons. The largest of the three press platens weighs 200 tons.

The horizontal draw bench has a 1200-ton rating. The overall length is 114 ft and the main cylinder bore diameter is 32 in. The operating hydraulic pressure is 3000 psi. No other such equipment exists in America today.

Library Service at Metals Show

The Special Libraries Association will give a demonstration of library service at the National Metal Congress in Philadelphia, Oct. 20th to 24th. The librarians will establish a quick reference service to be at the disposal of all visiting metallurgists and engineers. There will also be displays of the latest books and periodicals.

Visitors may participate in the Special Libraries Association, Metals Section, Regional Meeting at the National Metals Congress. Literature classification and mechanical methods for literature handling will be discussed in one session. Other topics include the organization and availability of research reports, how to obtain unclassified material from the government, and foreign language literature.

Resistance to bending is first measured to determine if steel can be drawn successfully.

Diameter of bend then measured. The smaller the diameter, the greater the tendency to stretcher strain during a draw.

Hand Operated Instrument Measures Drawing Quality of Steel

Has Proved Successful in Stamping Plants

A testing instrument invented by Charles B. Buker of Jones & Laughlin Steel Corp. quickly and simply measures the resistance to bending of cold-reduced sheet and strip steel, and thereby gives an accurate measure of the drawing quality of the material. A spherometer, also incorporated in the instrument, measures the diameter of bend in the sheet, giving an accurate determination of the susceptibility to stretcher strain in drawing. The instrument has been proven in stamping plants in the automobile industry.

The operator bends back a corner of the sheet, and the resistance to bending is measured on a dial. This shows ductility, translated into the probability of breaking the steel in a draw. Then the spherometer test is applied. The smaller the diameter of the bend, the greater the tendency toward stretcher strain.

The entire test takes less than a minute. None of the material is destroyed. Operators are easily trained. The instrument has been patented and will soon be available commercially.

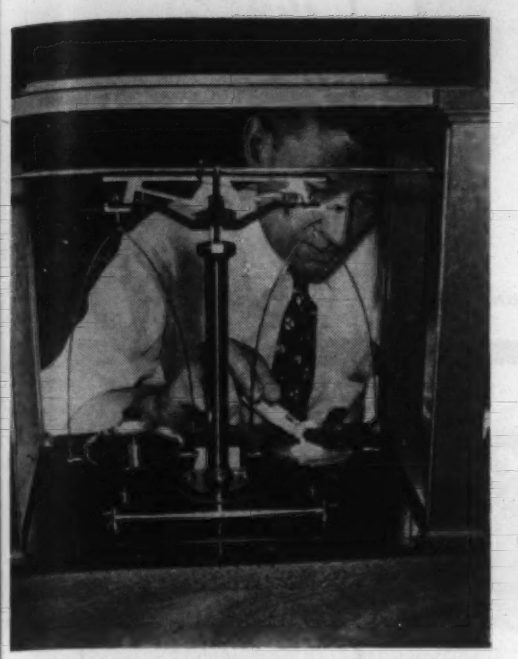
Chrysler Salvages Critical Industrial Diamonds

More Than 8800 Carats Recovered in 33 Plants

Recovery of more than 8800 carats of industrial diamonds from Chrysler Corp. manufacturing operations has emphasized the importance of nation-wide efforts to salvage these vital tools.

The Chrysler Corp. program is carried on in most of its 33 plants, where more than 7000 diamond-pointed tools and diamond grinding wheels are required for such precision operations as boring, lapping, reaming and grinding. Aluminum pistons, for example, are turned on a lathe with a diamond-pointed tool to measurements varying less than one ten-thousandth of an inch.

Diamond dust, or crushing bort, is used in grinding wheels to sharpen tungsten carbide tools. Most bort comes from African mines and costs about $5000 a lb. Diamond-pointed tools perform machining operations and are also required to true grinding



A. E. Chilcott, who heads Chrysler Corp.'s non-productive material control department, weighs 50 carats of diamond dust which was reclaimed from factory grinding.

wheels made either of diamond dust or sharp grains of corundum and other hard mineral combinations. As the wheels become loaded with particles of the material being ground, diamond-pointed truing tools are used to open up the grains and restore the surfaces to their original roughness.

"The demand for industrial diamonds presently exceeds the supply," according to A. E. Chilcott, who heads Chrysler's non-productive material control department. "This fact is of paramount importance in this defense period."

Chrysler Corp. has established a central depot and salvage program for recovering impressive quantities of industrial diamonds and dust from the swarf and sludge of diamond-bearing grinding wheels and tools. These recovered diamonds can be reused repeatedly. Swarf, which is dust produced in dry grinding, is recovered by machine attachments which suck the dust into collecting bags. The sludge from wet-grinding processes is saved in settling tanks which trap the diamond material and prevent its running off into the plant's disposal systems.

With the availability of a practical chemical process for separating industrial diamonds from the impurities in swarf and sludge, Chrysler Corp. launched its diamond salvaging program less than three years ago, and in that time has salvaged enough diamond material to meet 11% of its annual requirements. This is sold to concerns that supply the dressing tools to Chrysler.

World Leaders in Powder Metallurgy Meet in Tyrol

Latest Developments Point to Rapid Future Progress

The first Plansee Seminar "De Re Metallica" brought together about 300 powder metallurgists and physical metallurgists interested in the principles of powder metallurgy. The Seminar took place from July 22 to 26 and was organized by Dr. Paul Schwarzkopf and sponsored by his companies, the American Electro Metal Corp. in the country, The Metallwerk Plansee, in Reutte, Tyrol, and the Metro-Cutanit Ltd. in London.

Three series of lectures were presented, one on physical metallurgy, another on hard metals, and a third on general powder metallurgy.

Physical Metallurgy

Dr. H. Forestier (Strasbourg, France) talked on the effect of adsorbed gases on the reactivity of solid surfaces, and demonstrated that adsorbed gases may markedly change the melting points of crystalline substances as well as the transformation points of polymorphous substances in powder form. The speaker explained the observed effects by changes in the energy levels of the solid surfaces.

Dr. H. Nowotny (Vienna, Austria) reviewed the theories concerned with bonding in intermetallic phases. He attempted to find simple relationships between bonding character and hardness. For the refractory carbides he showed that the microhardness values, which do not

(Continued on page 13)

U. S. Captures Powder Metallurgy Leadership

The United States has wrested from Europe the distinction of being the world center of research in powder metallurgy, a scientist of Sylvania Electric Products Inc. said recently.

Dr. Henry H. Hausner, manager of atomic energy engineering of Sylvania's Atomic Energy Division, said that prior to World War II, Europe was the hub of scientific study and development of powder metallurgy, but that European scientists now look to the United States as the fountainhead of outstanding work in the field. Dr. Hausner pointed out that before the war, America's dominance in powder metallurgy extended only to production. Now, however, this country is the research leader, while the emphasis in Europe has shifted away from research and toward higher production.

"American metallurgists know," the Sylvania scientist commented, "that we had to set up a strong research system and a great deal of experimental work in order to establish the best, most efficient production methods. At present we are spending a great deal more money in powder metallurgical research than has ever before been spent anywhere in this field of science."

The European countries, he added, lack the funds required to conduct continuing fundamental research work. For economic reasons, they now are building up their powder metallurgical industry and are emphasizing manufacturing at the expense of research and development.

Dr. Hausner, who is one of the scientists engaged in Sylvania's program in the field of nuclear reactor materials for the U. S. Atomic Energy Commission, served as chairman of the powder metallurgy section of an international symposium on the reactivity of solids held in June at Gothenburg, Sweden, and later was one of the participants at the Plansee Seminar on Metallurgy held in Reutte, Austria.

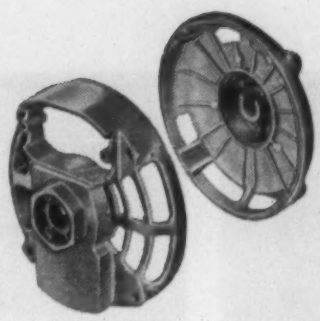
Reporting on recent developments abroad in powder metallurgy which were discussed at these conferences, the Sylvanian attached particular importance to work in Switzerland that has produced a new type of sintered aluminum noteworthy for its very high strength, particularly at high temperatures.

Aluminum strength is dependent upon grain size, Dr. Hausner explained, and grain size can be controlled more closely by powder metallurgy than by any other metallurgical technique. Due to its very fine grain structure, he said, sintered aluminum exhibits a greatly superior fatigue strength at high temperatures.

He also called attention to a new process developed in Germany by which, for the first time in history, continuous sheets and strips can be made from metal powders.

A third significant development is a new type of heating element introduced in Austria that may revolutionize the design of electric furnaces. These heating elements, he said, are made by powder metallurgical methods and consist of silicon-covered molybdenum. They have a high mechanical strength and can be heated up to 3100 in air.

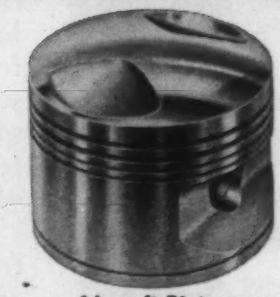
creative castings



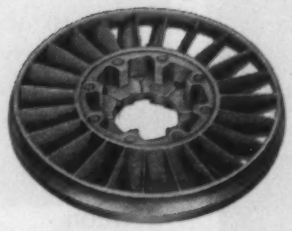
Motor End Frames

Gyrol Fluid Coupling

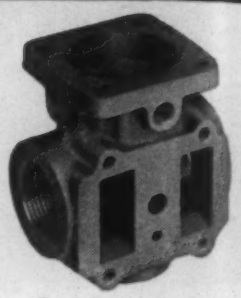
Garbage Disposer Housing



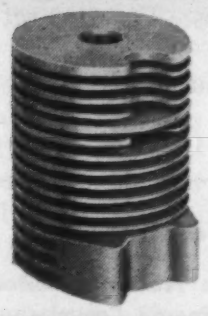
Aircraft Piston



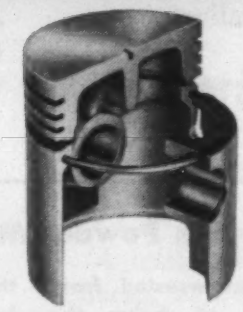
Torque Converter



Fuel Pump Body



Carbon Pile Regulator



Steel-Belted Piston

Alternator Housing

Diesel Permanent Mold Piston

Wing Actuator

Air Connector

Launching Barrel for Bazooka

For many years the foundry of Thompson's Light Metals Division quietly cast thousands and thousands of hard-to-make precision parts in light alloys of aluminum and magnesium.

Word got around that Thompson had the experience and facilities to cast light-weight, strong, heat-resisting alloy parts in permanent molds and high pressure dies—which eliminated the weight problems of ferrous counterparts. One by one manufacturers came to Thompson for help and advice when they learned that the close tolerances achieved by Thompson cut machining and finishing costs.

Today, our capacity is channeled to top-rated jobs. We're building additional facilities as fast as possible and, in the meantime, Thompson services, as always, are at your command. Our entire staff of creative engineers is ready to help you plan new parts or re-design old ones for the future.

A THOMPSON STORY TOO BIG TO HIDE!

Thompson Products, Inc.

2269 Ashland Road • Cleveland 3, Ohio

LIGHT METALS DIVISION

News Digest

continued from page 11

increase proportionally to the melting points, do decrease proportionally to the frequency factors.

Dr. G. M. Schwab (Munich, Germany) presented a paper entitled "Electron Theory of Mechanical Strength". Based on measurements of the temperature coefficients of the penetration hardness, he arrived at a relationship between the electron structure of metals and the energies required for formation and propagation of dislocations.

Dr. W. Seith (Munster, Germany) discussed new concepts of diffusion in metals. The recently established hole formation due to differences in diffusion rates will bring fundamental changes in the concepts of the diffusion mechanism. The experimental data given by the speaker were supplemented by color slides.

Dr. A. G. Smekal (Graz, Austria) talked about ideal and real crystals. He distinguished between structure-sensitive and structure-insensitive crystal properties, discussed the effect of lattice structures and chemical bonding types, and outlined the characteristics of ideal structure elements.

Among other papers presented in the series on physical metallurgy were those of Dr. M. Auwaztez (Balzers, Liechtenstein) on the stability of inorganic compounds in high vacuum, of Dr. A.Kofler (Innsbruck, Austria) on micro-thermal analysis, of Dr. R. Mitsche (Leoben, Austria) on hardness testing with hard metal indentors, and of Dr. F. Skaupy (Berlin, Germany) on present views on the nature of metals and their significance for metal ceramics (powder metallurgy).

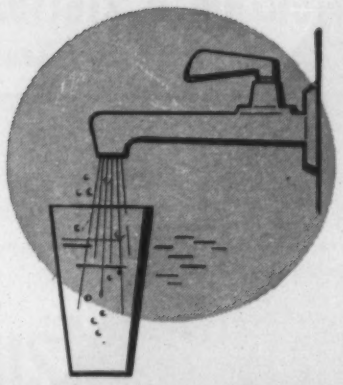
Hard Metals

Ing. C. Ballhausen's (Krefeld, Germany) talk was entitled "Properties of Hard Metal Alloys in Comparative Presentation". He gave a graphical presentation of the characteristic properties of tungsten carbide-titanium carbide-cobalt hard metals as a function of the composition, and suggested a standardization based on this presentation.

Dr. F. Fitzer (Vienna, Austria) talked about high-temperature mate-

(Continued on page 176)

where HARD RUBBER is right... use it!



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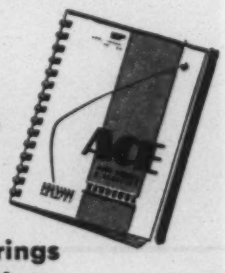
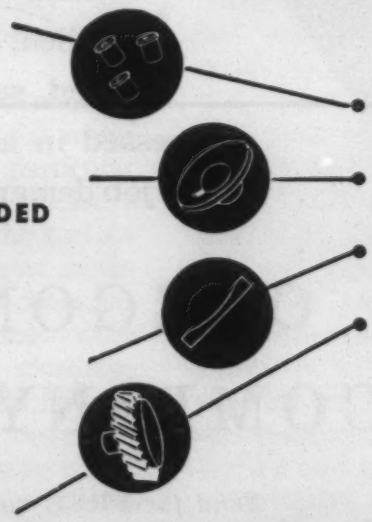


HINTS FOR PRODUCTION-MINDED ENGINEERS



- Meter bearings cut from tubes
- Disc molded over metal core
- Bearing plate punched from sheet
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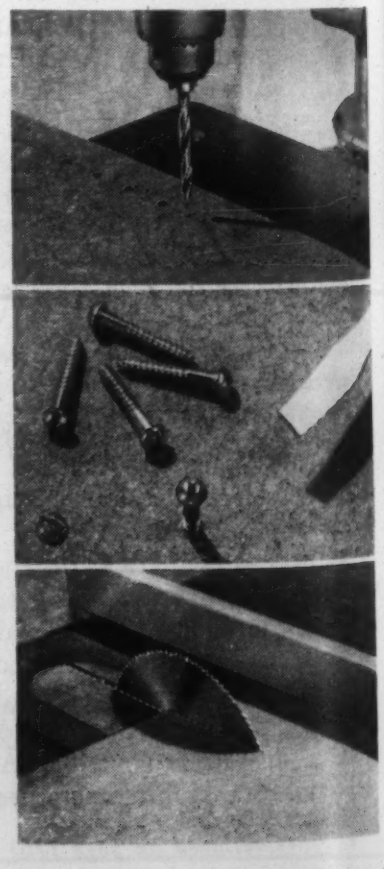

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Where Radioisotopes Are Finding Industrial Use

Thickness gages, wear tests, radiography, corrosion experiments and surface cleaning tests are all present industrial uses for the radioactive materials available from the Atomic Energy Commission.

by **PHILIP O'KEEFE**, Associate Editor, Materials & Methods

● RADIOISOTOPES ARE attracting a great deal of industrial interest today. While the number of isotopes being used in private industry is large, the volume of all these materials is still small. Most of the applications are in research. A few uses concern the practical materials selection man, however, and the general principles are of intellectual if not commercial interest to every engineer.

Radioisotopes are by-products of the atomic energy program. While natural radium was extremely scarce, the artificial radioactive materials are available in abundance, at least in view of the present demand. Various isotopes emit beta rays, while some emit the more penetrating gamma rays. Some isotopes emit both forms of radiation. Various half-lifes and a variety of radiation strengths are available.

The most important thing for the potential user to know is how radioisotopes are being used successfully. There are two general fields of industrial application: (1) tracers; and (2) radiation sources.

Tracers

A tracer is an element tagged with radioactivity for identification purposes. This tag follows the element through complicated chemical and physical processes. At any stage in a process, the amount of the radioactive element present and the places it is concentrated in can be found by radiation meters. The radioactive form of an element has for all practical purposes the same chemical and physical properties as the common form. Complex processes can be studied with radioisotopes which would be impossible to follow by other techniques.

The best known use of radioactive tracers is in analysis. Chemical research is a big customer. Radioactive chromium has been used to study plating processes. In metallurgy, diffusion in the solid and liquid states has been investigated. Radioactive carbon is being used to study carburization. While these applications are important scientifically, they are rarely a concern of the production or design engineer.

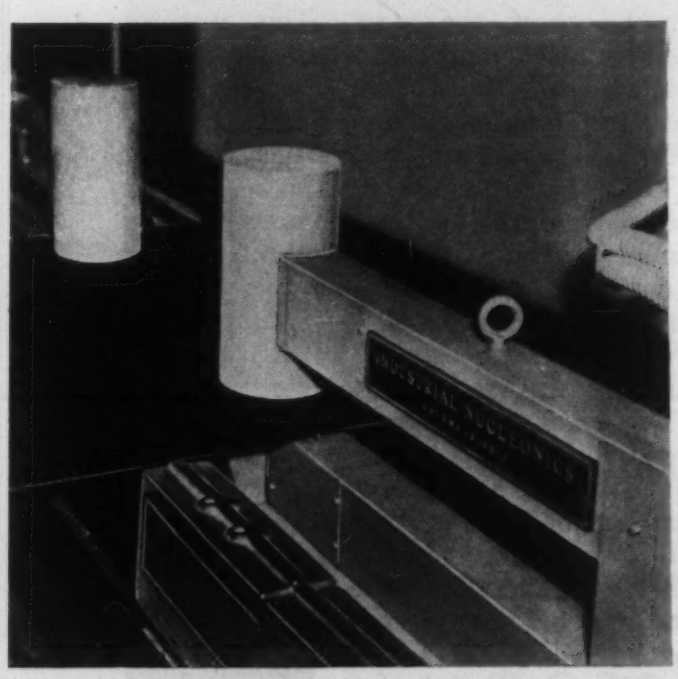
Another interesting application is in the evaluation of industrial metal cleaning methods. In one particular case, the problem was to measure how much oil was left on the surface after cleaning by the various methods. Gravimetric testing techniques, by which the specimens were weighed before and after cleaning, were not sensitive enough. Fluorescent dyes in the oil were better indicators, but the most sensitive test was by a radiation counter with an oil made with radioactive carbon.

Engine parts activated with nuclear fission products in an atomic pile yielded accurate and reproducible wear measurements in 2 to 4 hr. in engine tests. Several hundred test hours and an engine disassembly were required with the former methods. The old way was to assemble carefully weighed and measured pistons, rings, cylinder liners and bearings. The engine was then operated and taken apart. Visual inspection, measuring, weighing and photography show the wear. This was slow and expensive. Disassembly often made subsequent test results erratic. In the new method, the parts exposed to wear are made radioactive. The engine is run to break it in, the oil is drained, and an oil supply of measured radioactivity is put in. After the engine has been operated, the radioactivity of oil sampled varies with the amount of activated iron worn from the engine parts. This gives an accurate check on wear without taking the engine apart.

A similar application was made in studies of surface friction. One surface was made radioactive, then rubbed with another surface. The initially nonradioactive surface was then examined with a radiation counter to see how much of the first surface had been rubbed off. The result was quantitative and easy to get. Parts of the same metal could be used without confusion. These tests were designed to study the relationship between friction and metal transfer.

Five absorption beta ray gages, accurate within 1%, made by Industrial Nucleonics Co. are used at various stages on a 350-ft per min coated abrasive continuous processing line of the Coated Products Div., Carborundum Co. Continuous records are provided and production line adjustments can be made without stopping the machinery. Method is cheaper, faster and more accurate than previous techniques.

In general, radioactive tracers are used where small quantities of a material must be detected. The isotopes are easy and safe to use here. For very small quantities, diluted in other materials, the tracer method is usually most accurate. In analysis for large quantities and proportions, the new method may be out of the question, however, because of expense, shielding, requirements and comparatively low accuracy.



Absorption beta ray gage with Strontium 90 used by Dayton Rubber Co. to scan fabric as it comes from calender. Gage records thickness, weight and uniformity of rubberized or calendered fabric. Previous tests were conducted on a spot check basis. (Industrial Nucleonics Co.)

Radiation Sources

In other applications, radioisotopes are used as sources of radiation. The material is kept in a concentrated mass. The radiations are used for sterilization, radiography, luminescence, static elimination, in thickness gages and to initiate chemical reactions. Heretofore only radium was available for such uses, and its high price or the rental cost tended to limit its use.

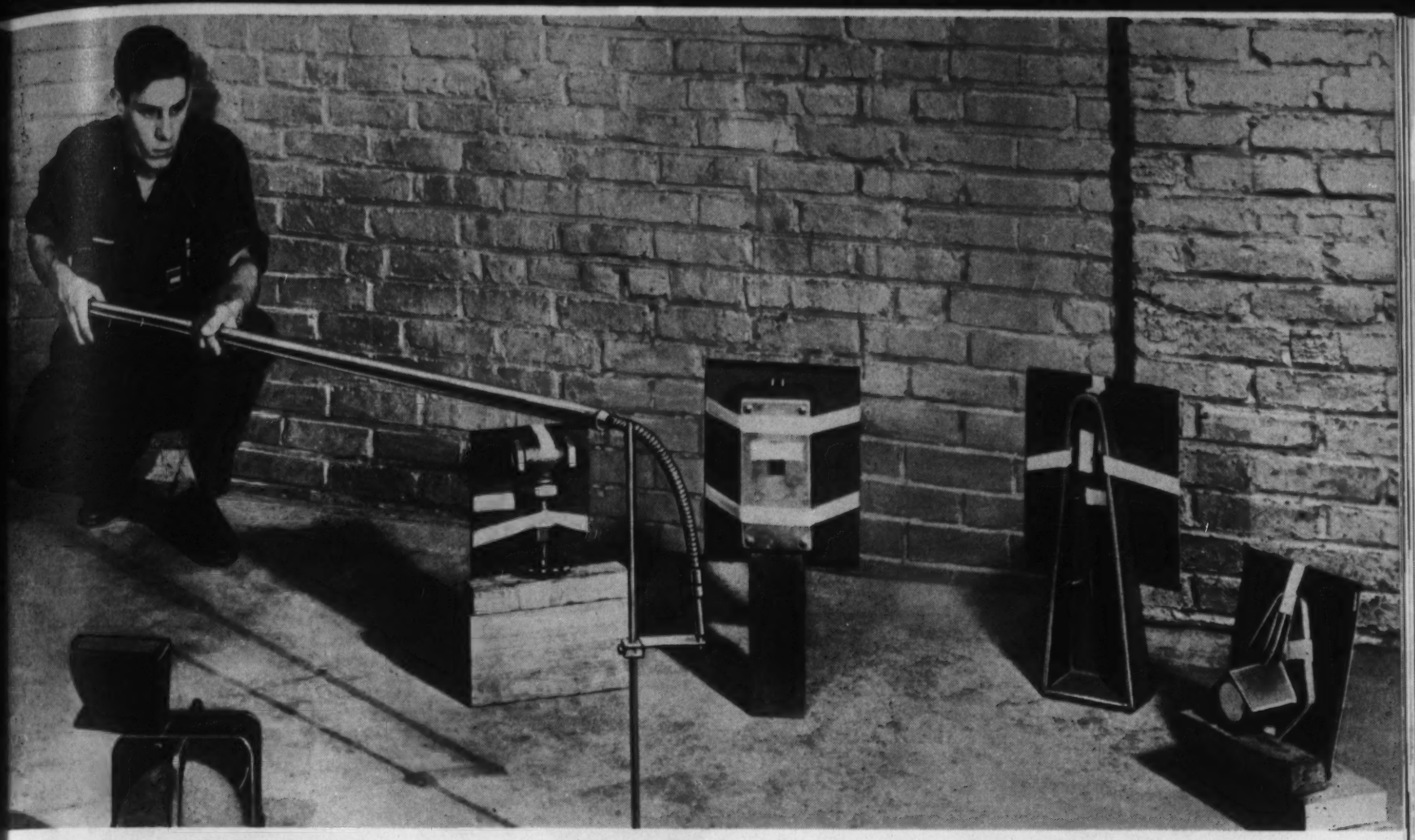
Gamma ray radiography received a big boost from the introduction of radioisotopes. Cobalt 60 is finding increasing use, and limited application is being made of iridium 192. In contrast to x-ray machines, isotopes are inexpensive and easy to move around. They are ideally suited for inspection of field work, such as pipe welds, pressure tanks and other engineering structures. In shops, they are readily moved around within large structures which could not ordinarily be positioned for x-ray examination.

Gamma rays have high penetrating power—equivalent to 1- and 2-million-volt x-rays. They can successfully penetrate 9 in. and more of steel. Gamma-ray radiography is especially suited for the detection of flaws in thick (over 1 in.) steel castings and welds. It is seldom used for the inspection of light metals and non-metallics. Gamma ray sources are also used to find the height of molten metal in containers. The availability and comparatively low price of the artificial isotopes makes gamma ray methods practical in many of these applications where radiographic inspection heretofore was too expensive.

As the radioactive materials get cheaper, luminescent paints and radioisotope static eliminators will be used more. Glowing paints depend on radioactivity for their phosphorescence. The radiations cause the phosphorous to glow. Static eliminators ionize the air in the path of their radiation and drain off electricity from nearby objects. This electricity is objectionable on paper sheets, for example.

Radioisotopes are also used in thickness gages. Beta ray emitters measure thicknesses with an accuracy of about 1 to 3%. These beta rays are actually high energy electrons given off by the radioisotope. Gages are now being used successfully on paper, paper coatings, plastics, plastic coatings, adhesive tape, thin metal sheets, photographic coatings, linoleum, metal foil and rubber. There are two types of gages—absorption and backscatter.

Absorption Gage—There are four elements in this instrument; a source



Cobalt 60 is finding increased use for detecting defects in castings such as these. (Tracerlab Inc.)

of beta radiation, an ionization chamber to detect and convert the radiation to electric current; a preamplifier to boost this current to measurable levels; and a meter to indicate fluctuations in this current. The radiation source is set up on one side of the sheet, and the beta rays pass through the material to be measured to the ionization chamber on the other side. Variations in the sheet increase or decrease the number of electrons absorbed before the radiations reach the detector. These variations are shown by the meter. Essentially, this setup weighs a small area of the sheet. If the density of the material is constant, the meter shows thickness variations. The clearance between the source and the detector in a typical commercial unit using strontium-90 as the source is 2 in. Material weighing up to 0.021678 lb per cu in. can be handled by the same unit. This corresponds to 0.030 in. of steel, 500 sheets of paper, 0.090 in. of aluminum, 0.250 in. of rubber and 0.200 in. of plastics.

Backscatter Gage—This instrument has the same components as the absorption gages. The radiation source and the detector are located on the same side of the sheet, however. The ionization chamber picks up diffusely reflected beta rays. The thickness of coatings on many types of base materials or the thickness of sheets passing over a calendar roll or other backing surface can be measured.

The use of this gage depends upon the atomic number and weight per unit area of both the material to be gaged and the backing material. The material to be measured and the backing are of different atomic number. The backing material must be thick enough so that variations in its thickness do not affect the amount of radiation that it will reflect back. Thus, variations in the coating thickness cause variations in the amount of radiation absorbed by the coating.

Backscatter gages are particularly useful where thicknesses across the entire width of a sheet must be measured or where it is inconvenient or impossible to use a detector on the opposite side of the sheet. The clearance between the detector and the sheet required in a typical unit is approximately 0.5 in. Material weighing up to 0.0090325 lb per cu in. can be measured with a typical unit using strontium-90 as the source.

Beta ray gages have a number of advantages. They can be used on delicate or easily marred surfaces, since there is no contact with the material. They are simple and cheap to operate. The gaging is continuous and a production record can be made. The results are unaffected by material content within limits, and the material speed can be as high as necessary. The absorption gages measure extremely thin materials impossible to gage by other methods. All this is done on a continuous basis, with no test samples or machine shutdowns required.

Using Isotopes

It is impossible to give specific instructions as to when to use radioisotopes and which one to use. Details of specific techniques or equipment used today are practically worthless to the man considering the general field. A bibliography on applications of industrial significance is available from the Technical Information Service, Oak Ridge, Tenn. The serial number of this publication is TID-5078. The Isotopes Div. of the AEC, also in Oak Ridge, will give information and assistance in developing any promising application.

When a company decides to use radioisotopes, they must decide whether to do the work themselves or farm it out. If the operation will be simple and repetitive, workers can be trained by the AEC. With more specialized work, it may be more economical to let outside research experts handle it.

Acknowledgments

We wish to acknowledge the help we have received from the personnel and publications of the following organizations:

American Petroleum Institute
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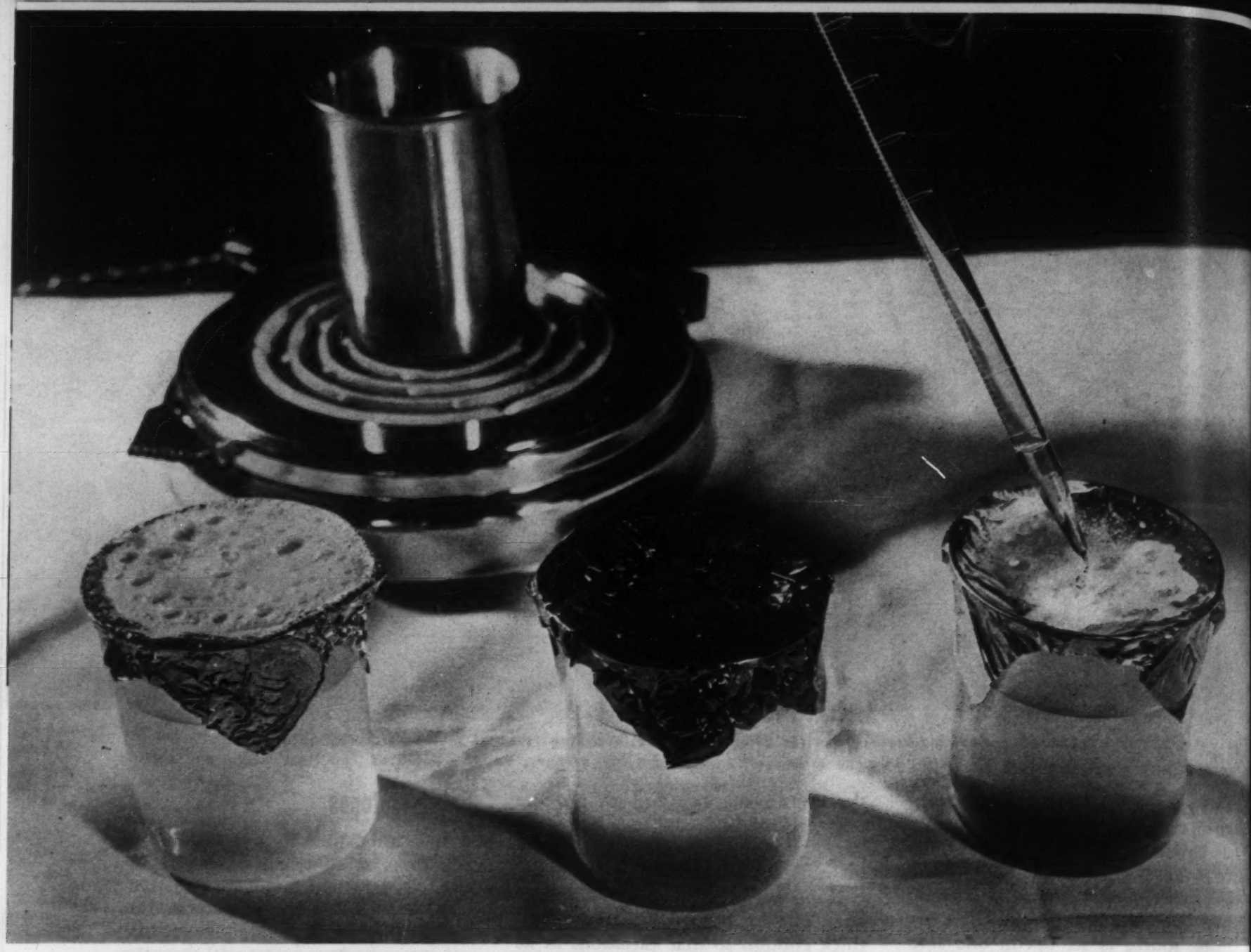
Nucleonic Corp. of America
Revere Copper and Brass Co.
Tracerlab Inc.
United States Atomic Energy Commission
Vitro Corp. of America



To demonstrate Epon's chemical resistance, three beakers of water are covered with aluminum foil. Left, foil is uncoated; center, top surface of foil coated with an Epon resin coating; right, foil has Epon finish on underside. Hot caustic poured onto foils eats away exposed foil on right and left beaker while center foil remains unaffected. After eating through foil on right, action is stopped by Epon coating underneath foil.

Epoxide Resin Coatings Have Excellent

Chemical Resistance
Adhesion
Abrasion Resistance

This combination of properties recommends them for container linings, caps and closures, washing machines, and chemical and processing equipment.

by T. R. HOPPER,
Shell Chemical Corp.

● THE DEVELOPMENT OF new and improved surface coating materials has progressed with such amazing rapidity that, where 30 years ago the engineer had only the natural resins and oils from which to choose, today, a seemingly endless variety of resins, plastics, cellulose derivatives, petroleum resins, and many other materials are available. To this growing list of surface coating materials, the Shell Chemical Corp. has recently added a group of epoxide resins, known as Epon,* which offer a new approach to the protective and decorative coatings industry.

* *Reg. Trademark—Shell Chemical Corp.*

The Epon resins are unique in that they are polymers built up through carbon-to-carbon and carbon-to-oxygen linkages. The fact that ester formation plays no part in this polymerization contributes to the outstanding chemical resistance of these resins. The resin is a linear polymer which can be produced in molecular weights giving products ranging from liquids to hard, pale solids. The resins, which are especially useful in the protective coatings industry, are Epon 1001, 1004, 1007 and 1009, whose melting points increase from 158 F, for Epon 1001, to 312 F for Epon 1009. Because of the reactive groups present in the polymer, it can be modified with a variety of materials in the production of both air-drying and baking finishes possessing heretofore unobtainable chemical and solvent resistance, flexibility and adhesion. The free hydroxyl groups in the polymer accounts for its ability to undergo the general reactions of alcohols.

The epoxide resins, as such, are not soluble in aliphatic or aromatic solvents. However, the aromatic types and some alcohols do exhibit latent solvency characteristics when used in conjunction with true solvents, which include ketones, esters and ether-alcohols. Typical solvent blends are equal mixtures by weight or volume of toluene and methyl ethyl ketone, toluene and Cellosolve acetate, toluene and acetone, and xylene and Cellosolve acetate.

The two most popular methods of using Epon resins in coatings are:

1. Cold cut the resin in conjunction with either urea-formaldehyde or phenol-formaldehyde for use in baking finishes.

2. The resin esterified with fatty acids for use in air-drying and baking finishes.

The esters can be formulated with linseed, dehydrated castor, soya, coconut, castor, oiticica, tall oil and other acids in oil contents ranging from about 30 to 60%. The shorter oil lengths, requiring xylene as the solvent, are especially useful in baking finishes where maximum chemical resistance and adhesion are required, and are compatible with urea and melamine resins. They are not, however, compatible with nitrocellulose. The medium and longer esters are soluble in high-solvency naphtha and mineral spirits, and will air dry rapidly to hard, tough, abrasion resistant finishes, adaptable for general utility finishes and trade sales items.

Recent development work has disclosed that through the use of ethylene diamine or diethylene triamine, coatings based on Epon 1001 can be cured at room temperature to films possessing excellent chemical resistance combined with outstanding adhesion and flexibility. Prepared in this way, coatings will become tack-free and hard in several hours, but maximum resistance properties require 5 to 7 days of curing. If diethylene triamine is used as the converting agent, the system can be baked, and in this way complete cure is expected in a matter of hours or even minutes.

Physical and Chemical Properties

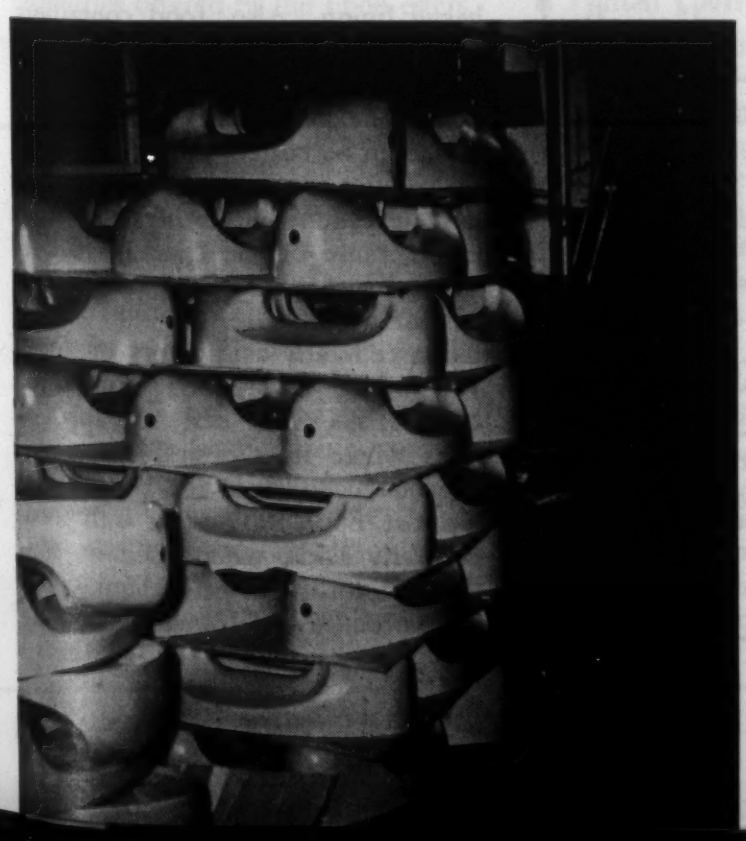
Adhesion—The adhesion of both the straight epoxide resins and their esters is outstanding. Properly cured films will withstand severe impact on both the film surface and the reverse side of test panels with no visible signs of failure.

Flexibility—The urea-formaldehyde-Epon resin baked films show excellent flexibility, but it is of utmost importance that these films be cured sufficiently. Under-curing is far more detrimental to flexibility than overcuring, and in the case of urea-Epon 1007-30/70 blend, flaking of the film under a knife scratch test will occur if insufficient curing time or too low a baking temperature is employed. The epoxide esters, both in air-dried and baked applications, also have excellent flexibility. Tin-plated panels will actually fail by breaking under repeated flexings before any signs of cracking, peeling or loss of adhesion are observed.

Abrasion Resistance—The abrasion resistance of the Epon resin-urea formaldehyde blends and the Epon resin esters is, in general, equal or superior to corresponding baked alkyd amine formulations, air drying alkyds, and oleoresinous systems. Practical walk-on tests have already proved the superiority of Epon resin formulations over conventional type floor finishes.

Chemical Resistance Properties—The greatest chemical resistance is obtainable with unesterified Epon resin-urea formaldehyde or phenolic blends cured at elevated tempera-

Epoxide resin coatings are ideal for home appliances such as washing machines where good adhesion, resistance to abrasion and to soap or detergents is required. Left, wringer shrouds, and right, base plates for washing machine chassis. (Whirlpool Corp.)



tures. This resistance is due to the fact that there are no ester linkages present in the resin. This eliminates the possibility of hydrolysis and splitting by reaction with alkali. Even prolonged exposure to hydrochloric acid, dilute and concentrated, has little effect upon the film. When modified by fatty acids, there is naturally some impairment in these properties, but Epon 1004 esters will show far superior chemical resistance when compared to an alkyd of corresponding oil length.

Color and Gloss Retention—Both of these properties are dependent upon the modifiers with which the epoxide resins are used. Ester formulations range from excellent, with the nondrying oil acids, to fair with the unsaturated, yellowing types of fatty acids. Gloss retention, generally speaking, is very good and even extended exposure to elevated temperatures has in many cases shown very little effect on this property.

Drying Characteristics—Cold cut epoxide resins used with urea-formaldehyde or phenol formaldehyde require baking at elevated temperatures, 300 to 400 F, to bring about complete cure. Schedules range from 30 to 40 min at 300 F to 2 to 4 min at 400 F, depending upon the system employed. Esters of the Epon resins will air dry in anywhere from 1 hr to 8 hr, depending upon the amount and type of modifier used.

Fields of Application

The properties outlined above make possible the use of epoxide resins in a wide variety of coating applications. Their outstanding adhesion makes coatings based on these resins suitable for application to metal surfaces, plastics, ceramics, rubber, wood, glass and leathers. The choice of vehicle depends upon the performance properties required of the coating.

As mentioned previously, maximum chemical resistance and adhesion are obtained by using the unesterified resin in conjunction with urea-formaldehyde or phenol-formaldehyde resins and curing at elevated temperatures. Such coatings, if properly cured, resist, almost indefinitely, attack from caustic solutions, solvents, mild acids, and many other chemicals and solutions. Therefore, this type of coating is recommended for washing machine primers, can and drum linings, coatings for caps and closures, and for top coats in special cases where these properties are desirable or necessary, such as for chemical plant equipment and refineries.

Epon resin brand primers for washing machines with only 10 to 20% the film thickness of a conventional alkyd primer showed tenfold improvement in detergent resistance tests as specified by the American Institute of Laundering.

Drums for flavor extracts, beverage concentrates, corrosive liquids, etc., which have hitherto been made, in many cases, from stainless steel, can now be made in the regular way if the interior receives an epoxide resin baked lining. Also, food containers can be given increased protection through the use of these coatings.

Pipeline coatings and oil well drill pipes can be coated with Epon resin formulations. These coatings will have excellent durability in these uses because of the chemical resistance, abrasion resistance and toughness of the film.

Linseed fatty acid esters of Epon 1004 make very good primers for exterior steelwork and for applications where it is desirable to have a good anchor coat for the enamel top coat. Epon 1007 esters with coconut fatty acids, when used in conjunction with urea or malamine resins, produce high-quality baking

Resistance to Chemicals and Solvents

Epon YP-100 formulation is unaffected by a three months' immersion in the following reagents at room temperature (all solutions are in water):

Alcohols
- Ethyl
- Isopropyl
- Secondary Butyl
- n-Butyl
- Methyl Isobutyl
- Neosol
- Neosol A
- Diacetone
- Hexylene Glycol
- Glycerine

Organic Chlorides
- Carbon Tetrachloride
- Allyl Chloride

Ketones and Aldehydes
- Methyl Isobutyl Ketone
- Formaldehyde (30%)

Cyclic Hydrocarbons
- Toluene
- Xylene

Bases
- Sodium Hydroxide (All Conc.)
- Ammonium Hydroxide (10%)

Ethers
- Diethyl Ether
- Bis (β-chloroethyl) Ether

Acids
- Acetic (1%)
- Linseed Fatty
- Sulfuric Acid (Up to 75%)
- Hydrochloric (Up to 20%)
- Nitric Acid (Up to 10%)
- Phosphoric (Up to 85%)

Miscellaneous Reagents
- Liquid Detergent (100%)
- Liquid Detergent (50%)
- Solid Detergent (1%)
- Resitoxaphene
- Sodium Methoxide (40% in Methanol)
- Sodium Chlorite (25%)
- Sodium Hypochloride (5%)
- Calcium Hypochloride (5%)
- Ferric Chloride (5%)
- Water
- Salt Spray at 100 F for 500 Hr

The coating is unaffected by the following materials, all exposures for 3 weeks at 150 F, except as noted:

- Isopropyl Alcohol
- Secondary Butyl Alcohol
- Methyl Isobutyl Carbinol
- Neosol
- Neosol A
- Diacetone Alcohol
- Hexylene Glycol
- Methyl Isobutyl Ketone
- Allyl Chloride
- 20% Sodium Hydroxide (Boiling, 24 Hr)
- 73% Sodium Hydroxide (280 F, 2 Weeks)
- Glycerine
- Glycerine (170 F, 6 Weeks)
- Water

Films slightly softened in one month's exposure at room temperature to acetone, methyl ethyl ketone, ethylene dichloride, hydrochloric acid (36%), sulfuric acid (78%), and hydrogen peroxide (15%). The coating has limited resistance to sulfuric acid (at concentrations greater than 85%) and hydrogen peroxide (at concentrations greater than 15%).

Lined with an Epon resin finish, this tank car carries corrosive chemicals.

enamels for a variety of uses. Machine tool finishes with good oil resistance and outstanding adhesion and mar resistance can be formulated from dehydrated castor or soy esters. Decorative enamels for all sorts of toys, metal furniture, typewriters, office and hospital equipment, and many other items can be made from a vehicle of this type. Esters with other types of fatty acids and tall oil acids are easily formulated, and depending upon the percent of acid used and the type, finishes for various industrial uses can be formulated.

Properties inherent to the epoxide resins, adhesion, flexibility and chemical resistance, are all present in the fatty acid esters. Short modifications, in the 30 to 40% oil length class, are generally used for baking purposes by spray application, and exhibit the maximum of the good properties offered by the Epon esters. Longer oil modifications, in the range of 50 to 55%, will air dry very satisfactorily and can be applied by either spray, brush, dip or roller coat.

Outstanding flexibility, excellent dielectric properties, and high heat and chemical resistance of epoxide resins contribute to their usefulness as wire enamels. Epon 1009, in conjunction with a heat converting phenolic resin, or Epon 1004 in an ester formulation with urea or melamine can be baked using conventional wire enamel baking schedules to insoluble and infusible films. These coatings are capable of withstanding elevated temperatures for extended periods of time with no deleterious effects, such as loss of adhesion or flexibility.

Regardless of metal used, collapsible tubes for shaving creams, tooth pastes, shampoos, etc. are afforded permanent beauty with epoxide resin coatings. Tests have been run on unfilled tubes in which the tube is telescoped rapidly to about 15% of its original length with absolutely no loss of adhesion, cracking, or failure of any kind. Their high gloss and excellent alkali resistance are very desirable properties for this use.

Because of the outstanding flexibility and adhesion demonstrated by these resins, they are useful in all applications where stamping, crimping or forming is carried out after the coating has been applied. This would apply to crown and cap closures, cans, tubes, etc.

A Typical Epoxide Resin Finish

Typical of the coatings that can be formulated with these epoxide resins is YP-100, which combines outstanding solvent and chemical resistance with the excellent flexibility, hardness, toughness, and abrasion resistance required in forming operations on previously coated metal.

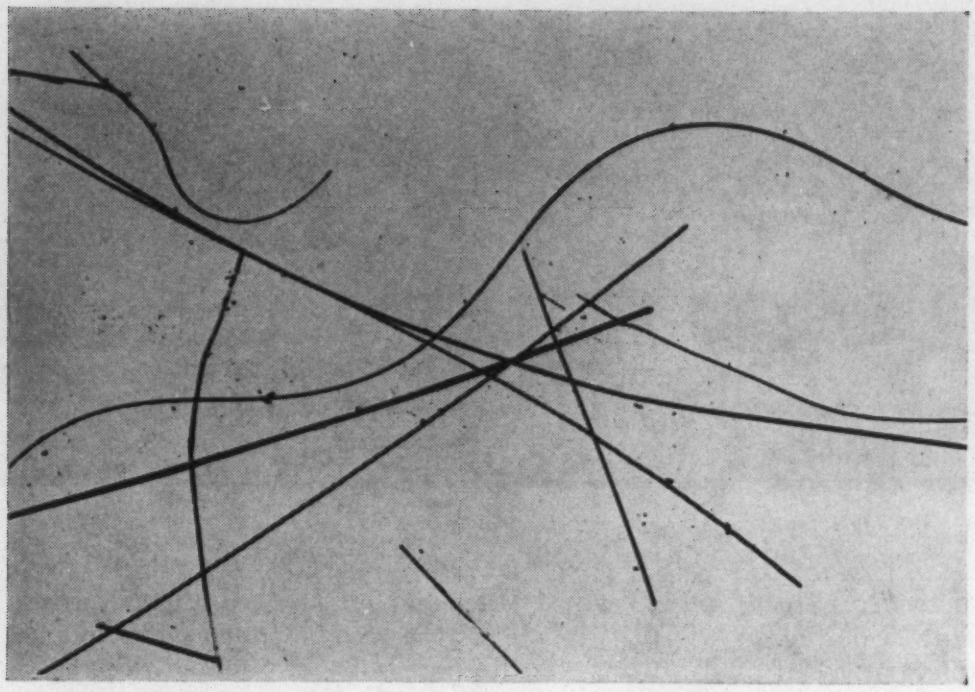
The coating is composed chiefly of Epon 1007 and a coating intermediate based on selected phenol derivatives developed by the General Electric Co., and known as R-108.

This system can be applied by spraying, dipping, flow coating, roller coating or brushing. The clear formulation has been successfully used in single-coat applications, but, whenever possible, multiple-coat systems are recommended which reduce the possibility of pinhole failure.

Repeated testing has shown that this finish, when applied and baked properly, has outstanding flexibility and adhesion on tin plate, solvent-cleaned cold-rolled steel (unprimed) and freshly sandblasted steel. Slightly reduced adhesion may be encountered on certain hot-rolled or hot-drawn steels. The coating is not recommended for coating aluminum or zinc when optimum adhesion is required.

This coating system has excellent corrosion resistance to a variety of chemicals and solvents, as can be seen from the accompanying table. This high corrosion resistance combined with its other excellent film characteristics suit YP-100 for many different applications. Some of them include: can linings that require exceptional flexibility and resistance characteristics; linings for storage tanks, drums, tank cars, and chemical processing equipment and piping; wire coatings; and industrial finishes for items used in corrosive atmospheres.

The epoxide resins are newcomers to the field of synthetic surface coatings, and all of their possibilities have not yet been explored. Work to date has shown them to be extremely versatile and useful, and it is felt that their introduction to the industry whose business it is to protect equipment and property of every conceivable nature will prove an important contribution.



Fiberfrax fibers as produced range in length from a fraction to 3 in. and in dia from 0.5 to 10 microns. (Magnification 100 X)

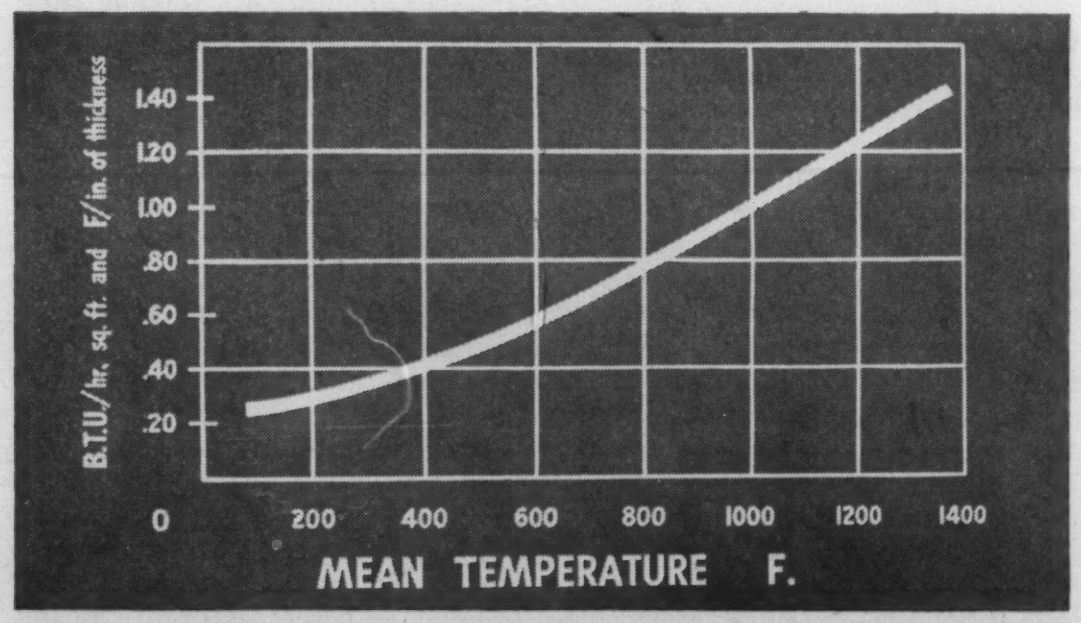
New Ceramic Fiber

● PRODUCTION OF A new ceramic fiber called Fiberfrax has been announced by the Carborundum Co. This fiber is made by melting aluminum oxide, silica and certain modifiers in an electric furnace and blasting a stream of the molten material with a controlled jet of air or gas. The product is a loosely matted material with the individual fibers ranging in length from a fraction to 3 in. and in diameter from 0.5 to 10 microns. Fiberfrax is available commercially only in bulk, at present. Further development is expected to lead to the production of felted blanket rolls, firmly bonded batts, tape and paper. The product is not suitable for spinning or weaving unless it is mixed with other fibers.

Fiberfrax is a fluffy material having a density as produced of 2 lb per cu ft. Its outstanding properties are resistance to high temperature, light weight, low heat transfer characteristics, excellent electrical properties and filtering efficiency.

The new fiber can resist temperatures up to 2300 F without deterioration in its properties and does not soften at temperatures approaching 3000 F. The insulating properties of Fiberfrax are such that it can compete with high quality cemented refractory brick even at the present pilot plant price of $1 per lb. Tests have shown that the time required to heat a furnace to a temperature of 2500 F is reduced 50%, and 30% less electrical power is required to maintain furnace equilibrium at that temperature when a lining of such refractory brick is replaced with Fiberfrax. The thermal conductivity is of the same order as that of glass fiber, but the new fiber retains its properties to a much higher temperature than glass fiber, which fails in the moderate temperature range.

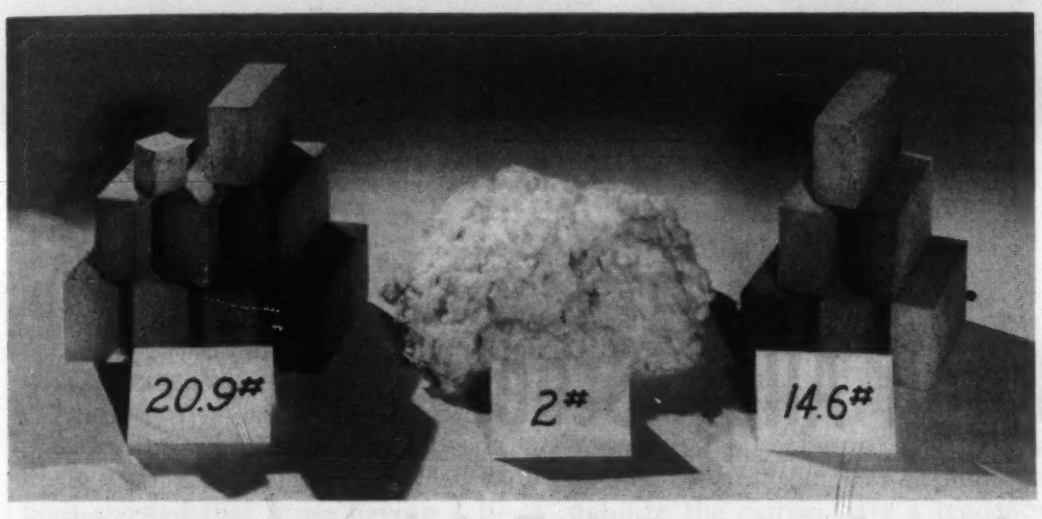
Paper prepared on the experimental machine at the National Bureau of Standards for Callinan and Lucas of the Naval Research Laboratory has been tested for use in flame resistance and electrical applications.



Thermal conductivity of Fiberfrax packed to the recommended density of 6 lb per cu ft.

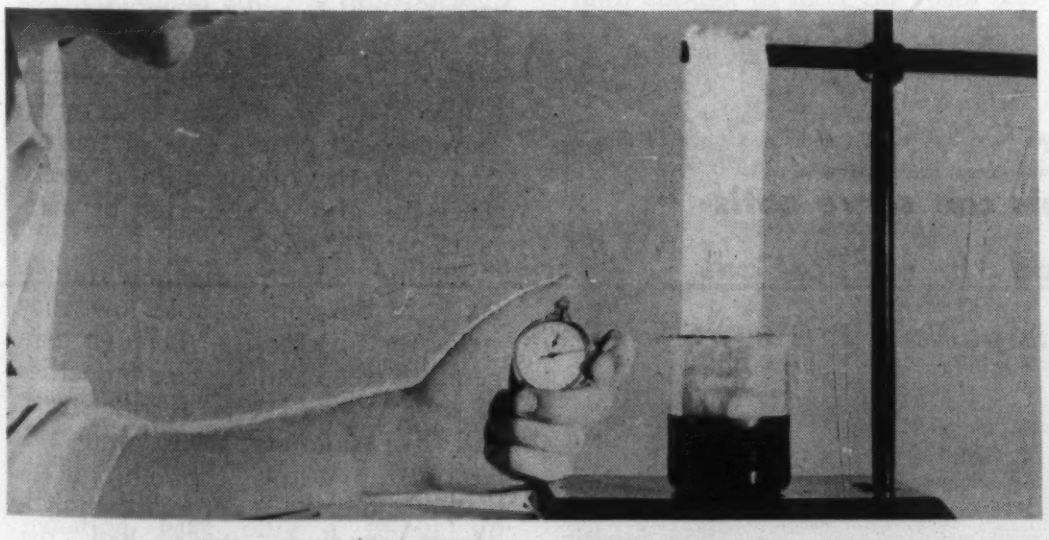
The ceramic fiber withstands furnace temperatures up to 2300 F without losing properties.

. . . . . Resists High Temperatures



Two lb of the new fiber packed to recommended density of 6 lb per cu ft fill the same volume as 14.6 lb of high grade insulating brick but furnish the insulating efficiency of 20.9 lb of the same brick.

. . . . . Is Excellent Insulator



Among other properties, the new fiber has pronounced filtering efficiency and capillary action. The outstanding capillary action is shown here.

. . . . . Has High Filtering Efficiency

The properties of paper made from 100% Fiberfrax are given in an accompanying table. This paper was mechanically weak, but Callinan and Lucas state that a glass fiber paper made with fiber of the same diameter would have the same strength although the density would be lower. The electrical properties of the Fiberfrax paper were excellent, losses being only one-fourth of those of Kraft paper.

The new fiber has definite possibilities as a filter medium. It is highly effective in removing fine particles in the smoke and fume ranges and is expected to become a useful filter medium for high temperature service particularly. Being resistant to most acids, such a filter could be cleaned readily with no danger of deterioration.

Applications

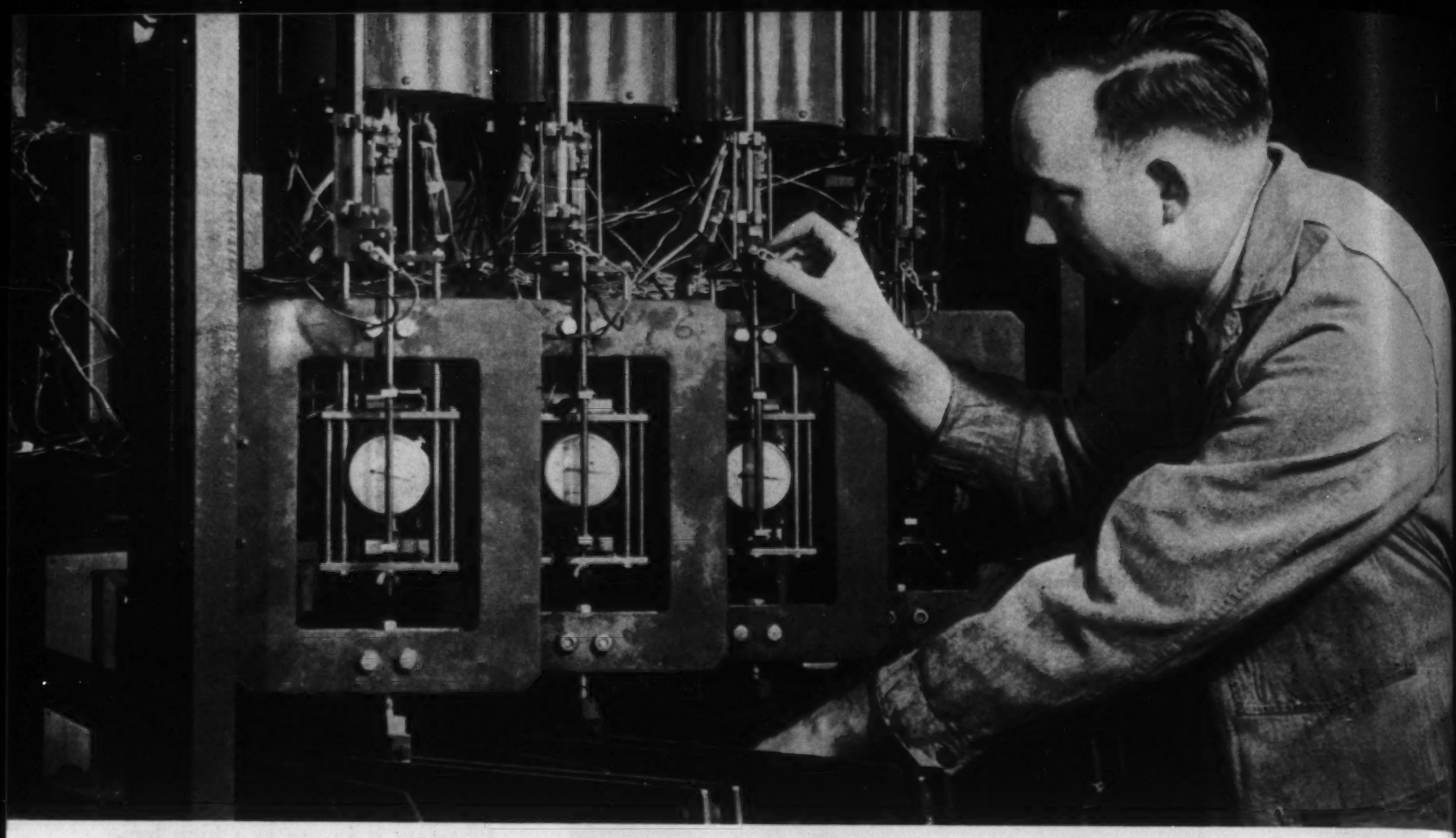
Fiberfrax is in use as a high temperature insulating material in the combustion and exhaust systems of jet engines and will be used to insulate high temperature furnaces to reduce the weight of the furnace and increase its efficiency. It is being investigated for use in special papers; as a replacement or partial replacement for asbestos; in thermal and electrical applications; for bonding into insulating panels, which will not only be resistant to fire but will deaden sound; and as a filter for gas and fume. Other possible applications include heavy duty brake linings, high temperature gaskets, vibration dampening devices, and flame filters to remove ash in gas turbines.

Properties of 100% Fiberfrax Paper

Thickness, In.	0.024
Tensile Strength, Psi	14
Tensile Strength Wet, 50% Moisture, Psi	41
Mullen Burst Test, Psi	1
Elmendorff Tear No.	7
Absorptivity	High
Porosity, Gurley-Sec	2.2
Air Resistance, Mm-Water/Mill	3.5
Dielectric Constant*	1.08
Power Factor*	0.02
Dielectric Loss Factor*	0.0002
AIEE Insulation Class	C

NOTES: *Paper produced without a binder on the experimental mill at the National Bureau of Standards.*

** at 60 cycles, 1000 cycles and 10 kilocycles (Callinan and Lucas, Naval Research Laboratory)*



Measurement of the flow of metals under load at elevated temperatures provides data for high temperature design at Westinghouse.

New Titanium-Boron Alloy Steel Shows Promise for Jets and Rockets

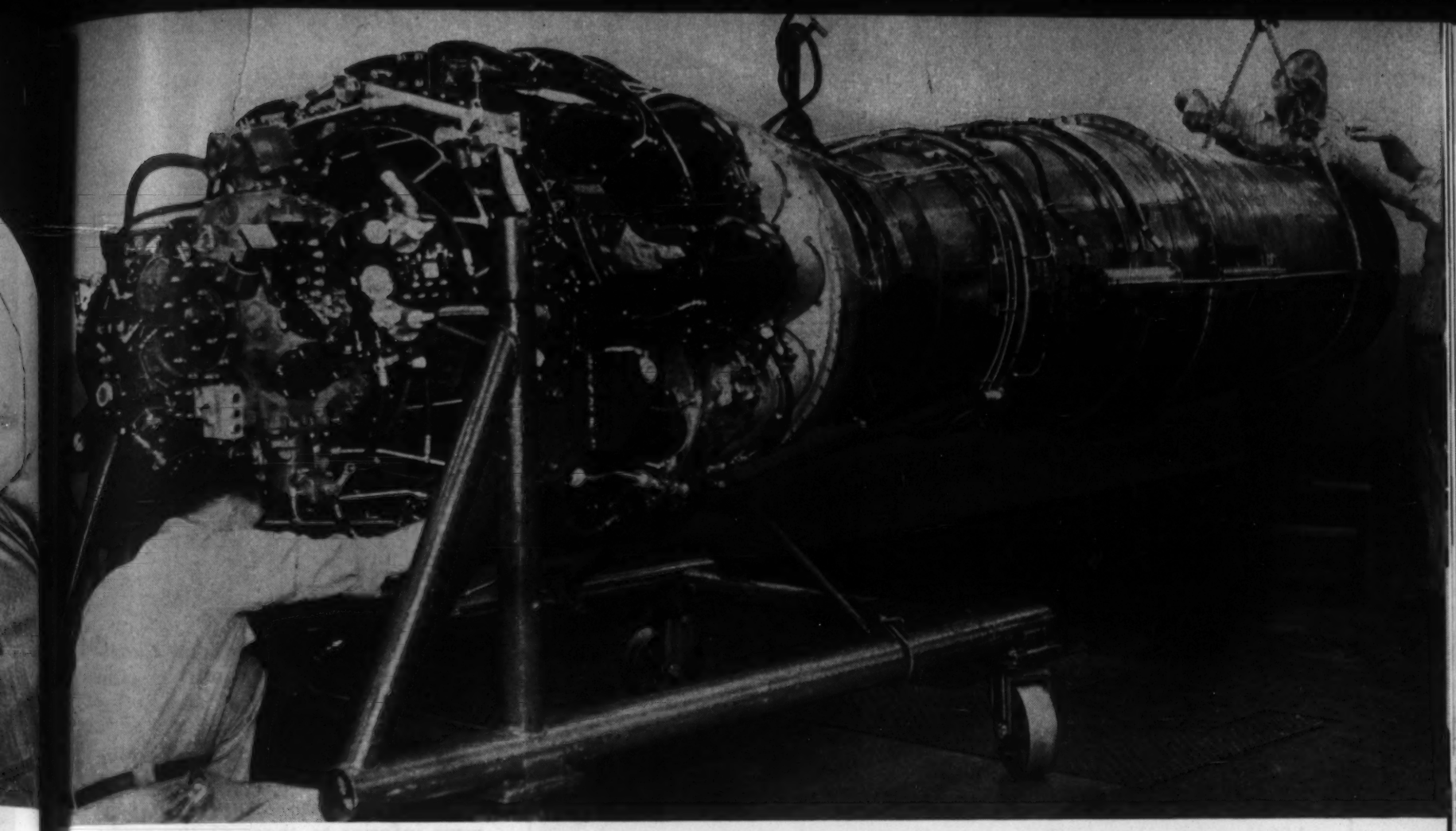
Reviewed by JOHN L. EVERHART, Associate Editor, Materials & Methods

Lean alloy steels such as this can serve satisfactorily for short life periods in applications where oxidation is not an important factor.

● IN THE DEVELOPMENT of materials for high temperature service, as in jet or rocket engines, emphasis has been placed on the use of highly alloyed metals to meet the extreme temperatures involved. However, there are a number of applications, for short life periods, where oxidation is not an important factor. For such applications, low alloy ferritic steels could be used advantageously. In the case of a demand for volume production of high temperature service components, the use of lean alloys in all possible applications would be imperative.

In addition to their strategic value, ferritic materials have other characteristics which make them attractive for moderately elevated temperature service. These include higher thermal conductivity, lower coefficients of expansion, and greater ease of fabrication than the highly alloyed steels. They can also be inspected by magnetic particle methods.

During an investigation undertaken to develop suitable low alloy steels for this service, the high temperature creep and rupture properties of six SAE, six special ferritic steels, and five stainless steels were determined. While the chromium-molybdenum and chromium-molybdenum-vanadium steels had the highest strengths of the standard low alloy compositions in the 800 to 1200 F temperature range, it was found that nitrogen, titanium and boron were more effective in increasing the high temperature strength



The new chromium-molybdenum-titanium-boron steel has good creep properties at 1200 F and can be employed for certain jet engine components. (Pratt & Whitney)

of ferritic steels than the more familiar elements.

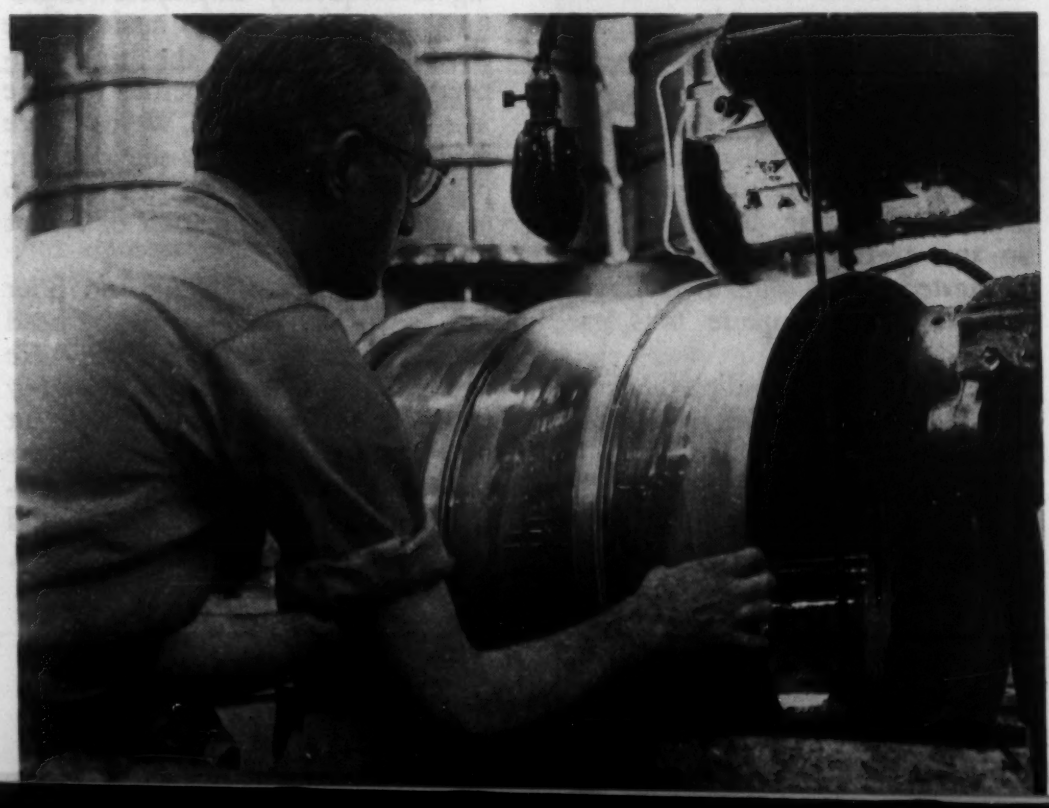
An intensive study on 30-lb laboratory melts of the titanium-boron steels with a number of alloy additions showed that those having a titanium-carbon ratio of 2 to 4 were superior to those in which the ratio was higher. Creep and rupture strengths at 1200 F increased continuously, with carbon increasing up to 0.20%, the maximum investigated. Titanium-boron alloys containing 2 to 3 chromium and 1% molybdenum had the best properties of all the alloys investigated. It was determined that boron variations from 0.010 to 0.10% had no significant effects on the high temperature properties at 1200 F, molybdenum was most effective in improving the hot strength of the titanium-boron steels, and chromium provided resistance to scaling and oxidation. It was found in this investigation that tungsten and vanadium added to the 3 chromium-1% molybdenum-titanium-boron steels to a maximum of 0.15% individually or in combination gave only a minor improvement in creep and rupture strength.

With these laboratory results as a guide, a 600-lb commercial heat of 3Cr-1Mo-Ti-B steel having a titanium-carbon ratio of 2 was produced for the investigation of the high temperature properties. The low titanium-carbon ratio introduced a problem, for it has been determined that high boron steels which do not contain sufficient titanium to stabilize the carbon have a tendency toward red shortness. By limiting the hot working temperature to 1850 F, it was possible to overcome the anticipated trouble and to forge and roll the alloy into sheet without difficulty. The room temperature tensile properties of the sheet were high enough to meet the room temperature requirements for gas turbine wheels.

Heat Treatment

In order to develop the desired high temperature properties in the Cr-Mo-Ti-B steels, suitable heat treatment is necessary. Temperatures sufficiently high to completely austenitize the steel and, in addition, allow maximum solution of the titanium, boron and carbides are required. Thus, these steels must be heated to 1900 to 2100 F. In sheet

Seam welding a stainless steel tail pipe casing at Pratt & Whitney. Procedures for welding the new titanium-boron steel are not yet fully developed.



Comparison of Creep and Rupture Properties at 1200 F

Material	Heat Treatment	Stress, Psi for 1% Creep in:				Stress, Psi for Rupture in:			
		1 Hr	10 Hr	100 Hr	300 Hr	1 Hr	10 Hr	100 Hr	300 Hr
3 Cr-1Mo-Ti-B*	2100 F in H_2, air-cooled	50,000	40,500	22,000	15,000	52,100	42,000	28,000	17,500
3 Cr-1Mo-Ti-B*	Preheated at 2100 F Hot rolled at 1850 F	—	43,000	23,000	16,000	—	47,000	26,000	18,000
18 Cr:8 Ni	Annealed	17,000	16,500	16,200	16,000	38,000	31,000	21,000	17,000
18 Cr-13Ni-2Mo	Annealed	17,000	17,000	17,000	16,500	37,000	33,000	28,000	25,500

** 600-lb heat*

Tensile Properties of 600-Lb Heat of 3Cr-1Mo-Ti-B Sheet

Composition, %	Condition	Ten Str, Psi	Yld Str, Psi	Elong in 2 In. %
0.065 C 0.34 Mn 1.06 Mo 0.022 B 0.28 Si 2.91 Cr 0.14 Ti	Norm. 1900 F	127,500	105,000	5
	Norm. 2100 F	124,000	96,500	7
	Preheated at 2100 F, hot rolled at 1850 F	143,000	110,000	9

form, full hardness can be obtained by cooling in air from the normalizing temperature.

Equivalent hot strength properties with improved ductility can be obtained from hot rolled sheet without subsequent normalizing. However, the slab should be heated to 2100 F for solution of the alloying elements and carbides and then cooled to 1850 F for hot rolling.

Elevated Temperature Properties

Creep tests were run at several temperatures to determine the rate of deformation as compared with those of other materials. It was found that for 1% deformation in 50 hr at 1200 F, the Cr-Mo-Ti-B steel supports a higher stress than any of the annealed stainless steels under the same conditions. For 1% deformation in periods up to 1000 hr at 1200 F, this alloy is superior to any of the low alloy steels investigated and to some of the highly alloyed steels. Rupture tests gave similar results.

Because of the low alloy content of the Ti-B steels, they are not notably resistant to corrosion or oxidation at high temperatures. At 1200 F for periods of several hundred hours, air oxidation is not prohibitive for sheet stock of the 3Cr-1Mo-Ti-B composition. However, at higher temperatures, scaling becomes a significant factor in causing premature failure, and tests were made with ceramic-coated samples to secure protection from oxidation. No superiority in strength was found with these coated samples at temperatures up to 1200 F. However, at 1400 F. the coated material is definitely superior to the uncoated sheet.

Welding Characteristics

In the fabrication of jet engine components from sheet stock, welding is frequently employed. Therefore, an evaluation was made of the effect of welding on the high temperature rupture properties of the 3Cr-1Mo-Ti-B steel. Welds were made by the inert-gas-shielded arc process using a copper back-up strip to minimize the formation of a heat tempered zone.

In one series of welds, no filler rod was used. Welds with the bead ground flush with the surface were tested at 1100 and 1200 F. They were not as strong as the parent metal and failure occurred in the edge of the weld metal. Normalizing the samples after welding did not improve the properties and, therefore, it is believed that the alteration in the titanium-carbon ratio during welding was responsible for the low values obtained.

In a second set, butt welds were made using a filler rod of type 347 steel. Short time rupture strengths were inferior to those of the parent metal in these tests also. However, in tests which exceeded 100 hr, the rupture strengths of welded specimens with the bead left on were close to those of the parent metal.

Although the welded joint high temperature rupture strengths were not equivalent to the parent metal, they were quite high. Since the failures were confined to the weld metal in both cases, further investigation of welding procedures and filler rods might result in improved welds.

The development of these alloys was done at the Cornell Aeronautical Laboratory under contract No. W-33-038 ac. 21094 with the Air Material Command in collaboration with the Research Laboratory, Titanium Alloy Manufacturing Div., National Lead Co.

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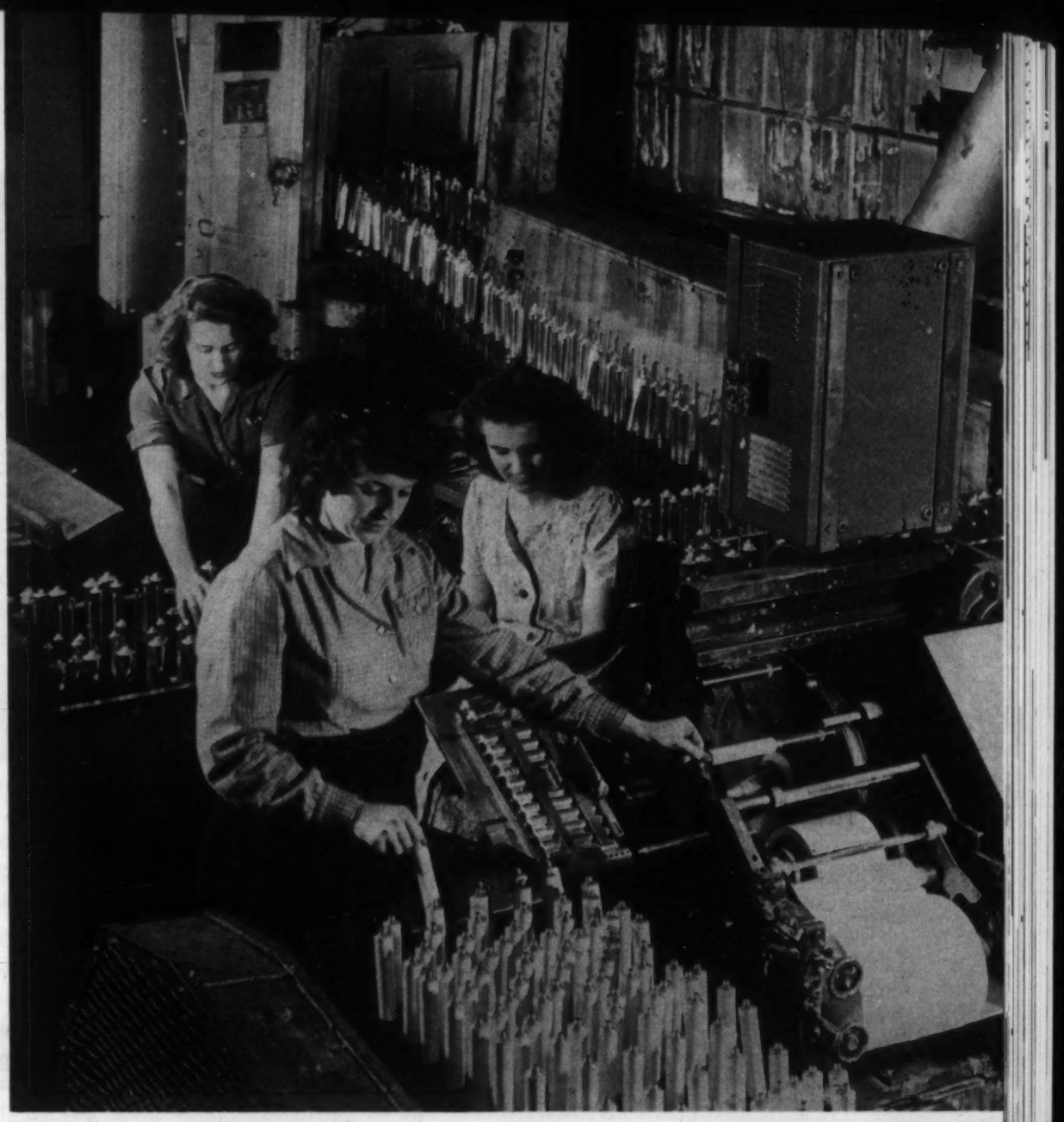


Before aluminum collapsible tubes are labeled, they are annealed in a continuous-type furnace (background).

How to Heat Treat Aluminum

by **FLOYD A. LEWIS**, The Aluminum Association

To take advantage of the wide range of properties obtainable through heat treating aluminum alloys, careful choice of method and equipment is essential.

● ONE OF THE principal reasons why aluminum is one of our most versatile metals is that it is available in an extremely wide range of tempers, or physical characteristics. Some of the temper variations are brought about by cold working the metal, some by heat treatment, and others by both methods. Heat treatment alone will produce tempers ranging from complete softening to high strength and hardness, depending on the temperature, time of treatment, and rate of cooling.

A number of heat treatments are used. Cast ingots are usually *preheated* before being rolled, forged, or extruded. This is done to improve the structure of the metal. *Annealing* is employed to remove the strain hardening resulting from cold working operations when the user wants the metal in this temper or when further cold working is necessary. Maximum strength can be developed in some alloys by a *solution heat treatment.* This may be followed by artificial *aging* for added strength or dimensional stability. Aging also is employed by itself for similar purposes.

The mechanism of heat treatment is involved intimately with the basic metallurgical behavior of the metal and its alloys. Only enough of the theoretical aspects of the subject will be introduced here, however, to facilitate an understanding of the various heat treatments, what they do, and how they are applied.

Preheating

Molten aluminum alloy does not solidify at one specific temperature, but over a range of temperatures. The structure of the metal is not uniform, but contains alloy constitutents of

varying proportions. For example, with a liquid alloy containing 4.5% of copper, the first crystals to form contain less than 1% copper. The continued removal of relatively more aluminum causes gradual enrichment of the melt. The last metal to freeze contains more than 20% copper, which is a brittle alloy. Thus, the grains vary from those at the center which contain less than 1% copper to those which contain 5.65% (the limit of solid solution) at the surface, while the richer alloy forms a network between grains.

The cast metal may also contain small amounts of intermetallic compounds of fixed composition. Such compounds may be formed between aluminum and the alloying metals as well as between the alloying metals themselves.

To make the metallic structure more homogeneous, ingots intended for rolling, forging and extrusion are first preheated. This treatment tends to equalize the concentration of alloying elements so that the ingot is more readily hot worked. To be effective, preheating must be done at relatively high temperatures for fairly long times. Depending on the type of alloy, the temperature will range from 900 to 970 F and the time from 4 to 12 hr.

Annealing

Annealing is used for either softening or removal of residual stresses. Since cold working causes strain hardening in aluminum alloys, annealing is particularly useful in producing wrought forms of the metal-sheet, plate, foil, rod, bar and wire.

Cold working alters the crystalline structure of the metal by producing fragmentation of the grains. The original structure can be restored by heating the metal above a certain temperature called the recrystallization temperature. When this recrystallization is complete, the metal is fully annealed.

Depending on the alloy, the temperature for complete annealing will range from about 650 to 800 F. For example, complete softening occurs almost instantaneously at 650 F for 2S and 52S, and at 750 F for 3S. These temperatures are not critical but should not be greatly exceeded. Lower temperatures require holding the material at those temperatures for longer periods. Rate of cooling is not important and should not be rapid enough to cause undue distortion of the material.

Most alloys susceptible to solution heat treatment (discussed in the next section of this article) can also be annealed at 650 F, while temperatures of 750 to 800 F are required for such high strength alloys as 75S. Annealing temperatures of these alloys must be held for 2 to 3 hr and must not be greatly exceeded. Slow cooling to about 500 F is recommended, and for alloy 75S the cooling rate should not exceed 50F per hr.

Annealing is employed between operations in production of wrought aluminum alloys in various forms and tempers. It is sometimes employed by the user as well, in fabricating the metal into end products. Fabricating operations involving considerable cold working may require the metal to be annealed between operations in order to be workable during final fabricating steps. Many fabricating processes, of course, involve only a moderate cold working, and in these cases, metal in a partially work hardened condition is used.

The final anneal that a nonheat treatable alloy receives is given so that cold work following the anneal will produce the desired temper. Attainment of this final temper sometimes requires only a partial anneal. Treatments of this type are given at lower temperatures than those ordinarily used for full anneal, to limit the degree of recrystallization of the metal.

Annealing treatments are usually not applied to aluminum alloy castings, although sand and permanent mold castings sometimes are so treated. The purpose of annealing castings is not for softening but to relieve residual stresses produced by unequal cooling rates in adjacent thick and thin sections and by contraction on hard cores and inserts. Temperatures employed are in the 600 to 700 F range, and the castings are held at these temperatures for several hours.

Recommended Conditions for Thermal Treatment of Common Wrought Aluminum Alloys

Alloy Designations			Annealing Treatment		Solution Heat Treatment[a] Temp, F	Aging Treatment	
ASTM		Common Commercial	Temp, F	Time, Hr		Temp, F	Time, Hr
New	Old						
990A	A2	2S	650	[b]	—	—	—
M1A	M1	3S	775	[b]	—	—	—
MG11A	MG1	4S	650	[b]	—	—	—
GP60A	CP21	11S	775[h]	2–3	950	320	12–16
CS41A	CS41	14S	775[h]	2–3	940	340	8–12
CM41A	CM41	17S	775[h]	2–3	940	—	—
CN42C	—	18S	775[h]	2–3	950	340	8–12
CG42A	CG21	24S	775	2–3	920	375[c]	7–13[d]
CS41C	CM21	25S	775[h]	2–3	960	340	8–12
SG121A	—	32S	775[h]	2–3	950	340	8–12
AL43	S2	43S	650	[b]	—	—	—
G1A	—	B50S	650	[b]	—	—	—
GR20A	GR1	52S	650	[b]	—	—	—
GS11B	GS22	53S	775[h]	2–3	970	350	6–8
						450	1–2
GS11A	GS21	61S	775[h]	2–3	970	320	16–20
						350	6–10
GS10A	GS2	63S	—	—	—	450	1–2
						350	6–8
ZG62A	ZG42	75S	775[e]	2–3	870[f]	250[g]	24–28

[a] *Soaking time varies with the product, type of furnace, and size of load. For sheet heat treated in a bath of molten salt, time may vary from 10 min for thin material to an hour for thick material. With air furnaces, times up to several hours may be required because the metal reaches heat treating temperature more slowly. A minimum of 4 hr is recommended for forgings.*

[b] *Time in furnace need be only long enough to bring all parts of load to annealing temperature.*

[c] *Cold working after solution heat treatment and before aging (precipitation) treatment is necessary to secure optimum properties.*

[d] *For extrusions, a time of 6 hr is recommended.*

[e] *Should be followed by heating for about 6 hr at about 450 F, if material is to be stored for an extended period before use.*

[f] *Sheet may be treated at higher temperatures (up to 925 F).*

[g] *Two-stage treatments comprising 4 to 6 hr at 210 F, followed by 8 to 10 hr at 315 F, or 2 to 4 hr at 250 F followed by 2½ to 3½ hr at 325 F, may be used for sheet or cold-drawn wire.*

[h] *This treatment is intended to remove the effect of heat treatment and includes cooling at a rate of about 50 F per hr to 500 F. Rate of subsequent cooling is unimportant. Treatment recommended for alloy 990A (2S) can be used to remove effects of cold work or partially to remove the effect of heat treatment if a completely annealed material is not required.*

Quenching a batch of small aluminum forgings after solution heat treatment.

Solution Heat Treatment and Aging

High strength aluminum alloys are obtained by using the solution heat treatment. In this treatment, the temperature is raised to a point slightly under the lowest temperature at which any of the alloy constituents will melt. The temperature is held at this level long enough for the alloying elements to go into solid solution in the aluminum. The metal is then suddenly cooled, or quenched, so that most of the alloying elements are held in solid solution. A more nearly homogeneous solid of the composition of the original molten alloy is the result.

For an alloy of aluminum to be responsive to solution heat treatment, it must contain at least one constituent, such as copper, which has greater solid solubility at elevated temperature than at room temperature. For best results, the amount of this addition should not exceed that which is completely soluble at temperatures just below the melting range of the alloy, although small additions of other alloying elements can be made.

Wrought alloys show a greater degree of improvement and require shorter times for completing the solution heat treatment process than casting alloys. Maximum strengths of more than 80,000 psi for wrought alloys and less than 50,000 psi for castings are attained. Such strengths are several times greater than those of the same alloys without heat treatment.

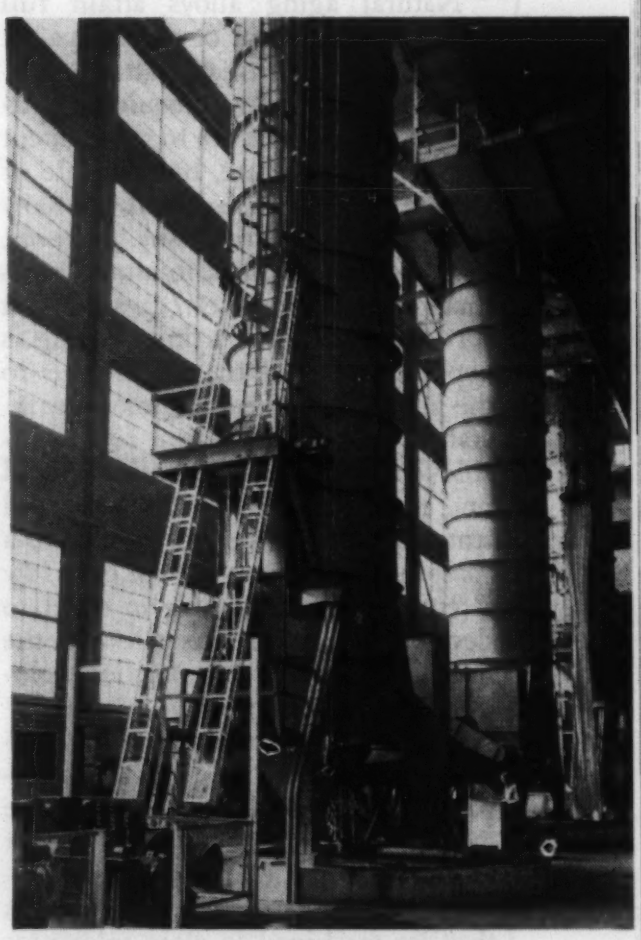
Hardness of the alloy also is increased by solution heat treatment, while ductility and elongation are reduced. Other characteristics are affected to a lesser extent.

Since the concentration of dissolved constituents in aluminum alloy that has been solution heat treated greatly exceeds solubility at room temperature, the alloy after quenching is in an unstable condition. Precipitation of alloying constituents from this supersaturated solid solution begins at once. The action is comparatively slow, however, because of low mobility of the atoms.

With notable exception of one forging alloy, there is further increase in tensile and yield strengths as the precipitation process proceeds. Depending upon the alloy, this aging or age hardening, as it is called, can be completed within comparatively brief time or continue for months. Other changes can be produced by artificial aging or precipitation heat treatment, which consists of holding the alloy at slightly elevated temperatures (usually in the range from 240 to 380 F) either immediately after solution heat treatment or after natural aging. The selection of conditions is a compromise between the use of as low a temperature as possible in order to develop maximum strength and the necessity for keeping time at a minimum to reduce manufacturing costs. Conversely, holding these alloys at a low temperature retards or completely arrests age hardening.

Temperatures used in solution heat treating range from 825 to 980 F, depending upon the alloy, and usually must be within 10 degrees or less of the required temperature. Maximum strengths in the alloy cannot be obtained at too low a temperature, while there is danger of melting some constituents at too high a temperature. The rate of heating may influence size of grains formed, and should be reasonably fast to prevent the formation of coarse grains if the material has been cold worked.

Soaking time, or the time during which the alloy is held at the treating temperature, may vary from 10 min to 12 hr or more, depending upon the alloy, type of furnace, and the thickness of sections. Sheet can be treated in the minimum time, whereas heavy forgings require the longest times. The time is measured from the instant that the coldest section reaches the minimum soaking temperature,



Vertical furnaces for heat treating aluminum extrusions. Note quenching pits at base of furnaces.

and is so chosen as to put substantially all of the soluble elements into solid solution. Too short a time results in incomplete solution, and too long a time may result in difficulties with oxidation and with diffusion in so-called "cladded" materials, which are composed of two different alloys. The exact times are usually adjusted by experience.

At the end of the required soaking

period, the material must be cooled rapidly to retard or prevent a recurrence of the original conditions. For some alloys the time interval between removal from the furnace and quenching is critical and must be held to a minimum; the permissible maximum time may be as little as 10 sec.

The method of quenching employed depends upon the form of the work, the alloy, and the properties desired. Typical recommendations are for the quenching of most casting alloys in water at 150 to 212 F, with preference for boiling water to minimize stresses and distortion, and for the quenching of wrought alloys in cold water, although bulky sections may call for water at 140 F or more. Oil baths, water sprays and air cooling are other methods that can be employed.

Natural aging alloys attain full strength within four or five days after quenching, and usually attain 90% after 24 hr. Alloys requiring artificial aging also harden to some extent at room temperature, but the rate of change in some instances is too slow for practical benefit. Many, however, can be placed in stock to attain maximum strength in a few days without further treatment. Artificial aging is applied by raising the temperature to the precipitation heat treatment temperature and maintaining it for a suitable length of time. Variation should not exceed ± 5 F. The time and temperature must be worked out to a compromise between the use of as low a temperature as possible in order to develop maximum strength, and the limitation of time for practical commercial production.

Small changes in dimensions, commonly spoken of as growth, accompany the age hardening process. The magnitude of change is insignificant in natural aging, but may require consideration in artificially aged pieces that are machined to close tolerances prior to aging. If artificial aging is continued long enough, practically all of the growth to which aluminum alloys are subject may be consummated during the heat treatment process. These treatments are called overaging or stabilizing treatments and are employed where a high degree of dimensional stability is required. Some loss of tensile and yield strengths occurs in the process so that a compromise often becomes necessary.

Aging treatments are sometimes given without solution heat treatment, especially with permanent-mold castings which come from the molds in semi-solution-treated condition. Stabilizing aging treatments also are given without prior solution heat treatment.

Intentional retardation of the aging process sometimes may be desirable, and can be accomplished by refrigeration. For example, rivets can be stored at low temperature to be kept soft until driven, after which age hardening takes place at room temperature.

No harmful effects result from the repetition of the heat treatment of the bare aluminum alloys, although protection against possible high temperature oxidation during the heating cycle is advisable. Sodium or potassium fluoborate can be used for the purpose. Cladded alloys, however, are extremely limited as to number of resolution heat treatments because of diffusion.

Following solution heat treatment, some straightening and flattening operations may be necessary to remove warping and kinking. Depending upon the alloy, some changes in physical characteristics can be expected to result from this work.

The effects of solution heat treatment can be removed by annealing. A 2-hr soak at 750 to 800 F, followed by cooling to 500 F at a maximum rate of change of 50 F per hr, can be employed when maximum softness is desired. A 1-hr soak at 640 to 660 F, followed by air cooling, is generally satisfactory if maximum softness is not required.

Various difficulties can arise in solution heat treatment as a result of procedures or prevailing conditions during the process. Both insufficient heating, as by the use of too short a soaking time or too low a temperature, and overheating can cause tensile and yield strengths to be too low. High temperature oxidation, slow quenching, and slow transfer from heating period to quenching are other causes of low strength. Overheating also can lead to the formation of blisters on the surface and to the occurrence of cracks during quenching.

Improper support of the material being treated can result in excessive warpage and distortion, although these difficulties also result from improper heat distribution in the furnace or a drastic quench. In turn, the excessive straightening and flattening that is required can result in low elongation, accompanied by an abnormally high yield strength.

The atmosphere in which the heating is done is important because of the effects of moisture content and combustion products. Any trace of sulfur compounds is particularly harmful. Safe atmospheres have been found to be air with a low moisture content and a mixture of air with combustion products, provided the latter comprise about 33% or more at all times during the heating cycle. The cladded alloys are not attacked in commercial heat treating operations.

Improper quenching or improper reheating after solution heat treatment renders some alloys susceptible to intergranular corrosion when exposed to corrosive conditions. This results in drastic lowering of tensile strength and elongation in those alloys. If a salt bath is used for heating, care must be taken to remove all traces of salt upon removal of the work from the bath, particularly in recesses in castings.

Equipment

Selection of furnaces for heat treating aluminum alloys must take into consideration such factors as uniformity of temperatures available, facility of operation, freedom from undesirable reactions with the alloys being treated, and costs, both initial and operating. Fuels used can be gas, oil or electricity; heat can be transferred to the work by air, oil or molten salt.

Gas and oil fired furnaces for air heating can either expose the alloys being treated to products of combustion or use a recirculating air system for heating. The latter type is advantageous because by use of high air velocities rapid and uniform heating can be attained. Air furnaces have the advantage that temperature can be varied rapidly if the same equipment is used for treating several alloys. Although reasonable, the initial cost is higher than for salt baths; operating costs, however, are lower.

Salt baths are the most commonly used of the liquid baths. Oil baths present a potential fire hazard, and usually tend to be messy. The salts used in various mixtures are sodium and potassium nitrates and sodium nitrate. The addition of an inhibitor is desirable. Salt baths are critical in operation, and care must be taken

that no water is introduced with the work being treated to prevent an explosive formation of steam. Some of the bath is removed with the work, requiring replenishment of the bath and thorough washing of the finished work. However, heating rates are very fast and temperatures are usually uniform, so that these baths are ideal for small parts, mixed loads, and large thin sections. The difficulty of cleaning castings may discourage the use of salt baths for this class of work.

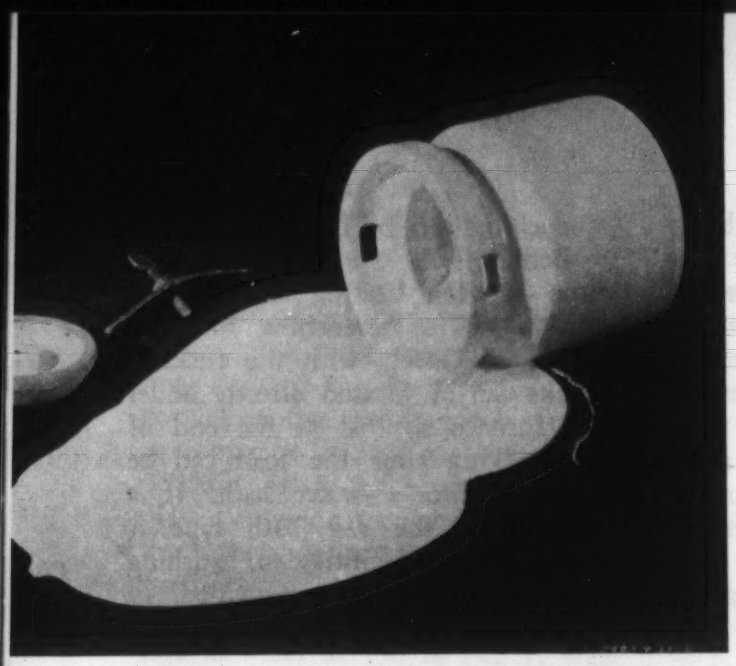
For small operations, furnaces of the pit type can be used, but for large scale operations, car type and continuous furnaces are preferable. The weight of a single charge may run from at little as 100 lb to more than 10 tons. With the continuous type furnaces, greater uniformity of temperature and more definite and shorter intervals between heating and quenching can be maintained.

Because of the critically short time between heating and cooling, equipment for quenching must be associated closely with the furnace. Tanks can be located directly under the furnace so that at the end of the soaking time the load can be dropped into a water bath. If a furnace of the salt bath type is used, suitable facilities for washing the work also must be provided.

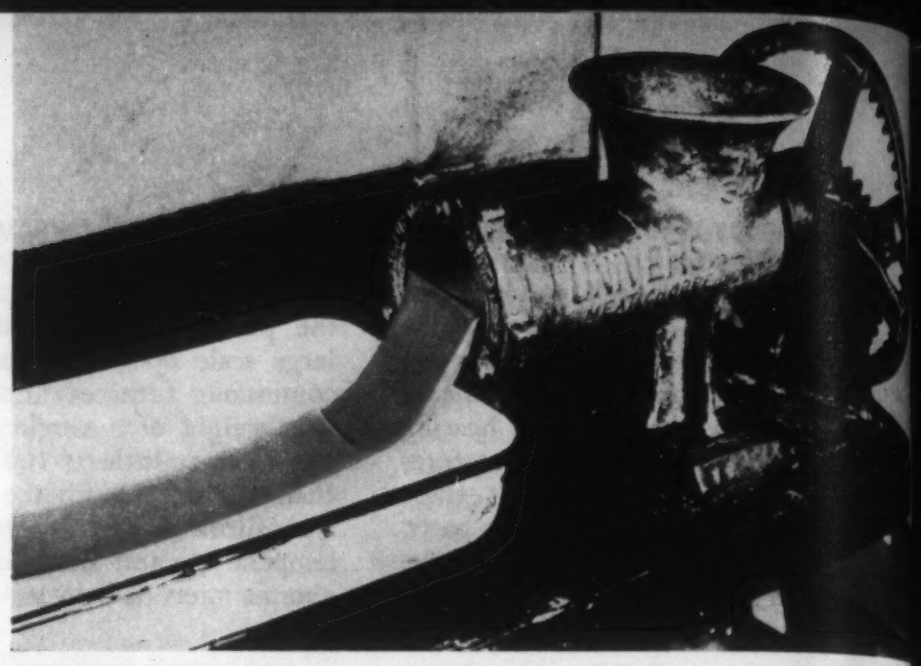
Recommended Heat Treatments for Commercial Aluminum Casting Alloys

Alloy (ASTM)				Solution Heat Treatment			Aging Treatment	
New	Old	Type of Casting	Type of Treatment	Time Hr[a]	Temp, F[b]	Quench[c]	Time, Hr[d]	Temp, F[b]
CG100A	CG1	Sand	Anneal	—	—	—	2–4	600
		Sand	Sol. and Stab.	12	950	Water	10–14	310
		Perm.	Aging	—	—	—	5–7	310
		Perm.	Stab.	—	—	—	18–22	340
		Perm.	Sol. and Aging	8	950	Water	7–9	340
CN42A	CN21	Sand	Anneal	—	—	—	2–4	650
		Sand	Sol. and Stab.	6	960	Still air	1–3	650
		Perm.	Stab.	—	—	—	22–26	340
		Perm.	Sol. and Aging	6	960	Water	3–5	400
C4A	C1	Sand	Sol.	12	960	Water	—	—
		Sand	Sol. and Aging	12	960	Water	3–6	310
		Sand	Sol. and Stab.	12	960	Water	12–20	310
CS42A	CS4	Perm.	Sol.	8	950	Water	—	—
		Perm.	Sol. and Aging	8	950	Water	5–7	310
		Perm.	Sol. and Stab.	8	950	Water	4–6	500
CS66A	CS23	Perm.	Aging	—	—	—	5–7	525
		Perm.	Sol. and Stab.	8	920	Water	2–4	525
SC51A	SC21	Sand	Aging	—	—	—	7–9	440
		Sand	Sol. and Aging	12	980	Water	3–5	310
		Sand	Sol. and Stab.	12	980	Water	8–10	310
		Sand	Sol. and Stab.	12	980	Water	4–6	475
SC64B	SC8	Sand	Sol. and Aging	12	940	Water	2–5	310
		Perm.	Sol. and Aging	8	940	Water	2–5	310
SC64C	SC9	Sand	Sol. and Aging	12	940	Water	2–5	310
		Sand	Stab.	—	—	—	7–9	400
		Perm.	Sol. and Aging	8	940	Water	3–6	310
SC82A	SC42	Sand	Sol.	12	980	Water	—	—
		Sand	Sol. and Aging	12	980	Water	8–12	300
		Sand	Sol. and Stab.	12	980	Water	8	440
SC122A	SC41	Perm.	Aging	8	960	Water	8	390
		Perm.	Sol.	8	960	Water	—	—
		Perm.	Sol. and Aging	8	960	Water	8–12	300
		Perm.	Sol. and Stab.	8	960	Water	8	440
SG70A	SG1	Sand	Aging	—	—	—	7–9	440
		Sand	Sol.	12	1000	Water	3–5	310
		Sand	Sol. and Stab.	12	1000	Water	2–4	475
		Perm.	Sol. and Aging	8	1000	Water	3–5	310
		Perm.	Sol. and Stab.	8	1000	Water	7–9	440
SN122A	SN41	Perm.	Stab.	—	—	—	14–18	340
							7–9	400
		Perm.	Sol. and Stab.	8	960	Water	14–18	340

[a] *Soaking time periods, after load has reached specified temperature, required for average casting. Time can be decreased or may have to be increased, depending on particular castings as demonstrated by experience.*
[b] *Temperature setting for control instrument. Variation of temperature in furnace should not exceed plus or minus 5 F.*
[c] *Water temperature from 150 to 212 F can be employed. Boiling water recommended since it minimizes quenching stresses and distortion.*
[d] *Exact time required influenced by foundry variables. Select on basis of obtaining typical mechanical properties.*



PLASTISOL *is a dispersion of finely divided resin in a liquid plasticizer. Unlike organosols, plastisols contain no volatile constituents. (The Goodyear Tire & Rubber Co.)*



PLASTIGELS *can be extruded into a hot bath. The liquid supports the extrusion and gives high heat transfer. (Bakelite Div.)*

Vinyl Plastisols and Plastigels

What They Are Where They're Used

by **PHILIP O'KEEFE**, Associate Editor, Materials & Methods

These vinyl dispersions cure with heat and little or no pressure to durable, rubber-like products. Spread coating, film casting, dip coating, slush molding, cavity molding, injection molding, extrusion and spraying are all practical forming methods.

● MANY FLEXIBLE PARTS and products which require the special chemical or mechanical properties of vinyl plastics are made with plastisols and plastigels. These compounds are valuable because they can be formed easily into many products that could not be made of vinyl materials by conventional methods. They are also chosen over rubbers for some products because of fabricating advantages.

Plastisols

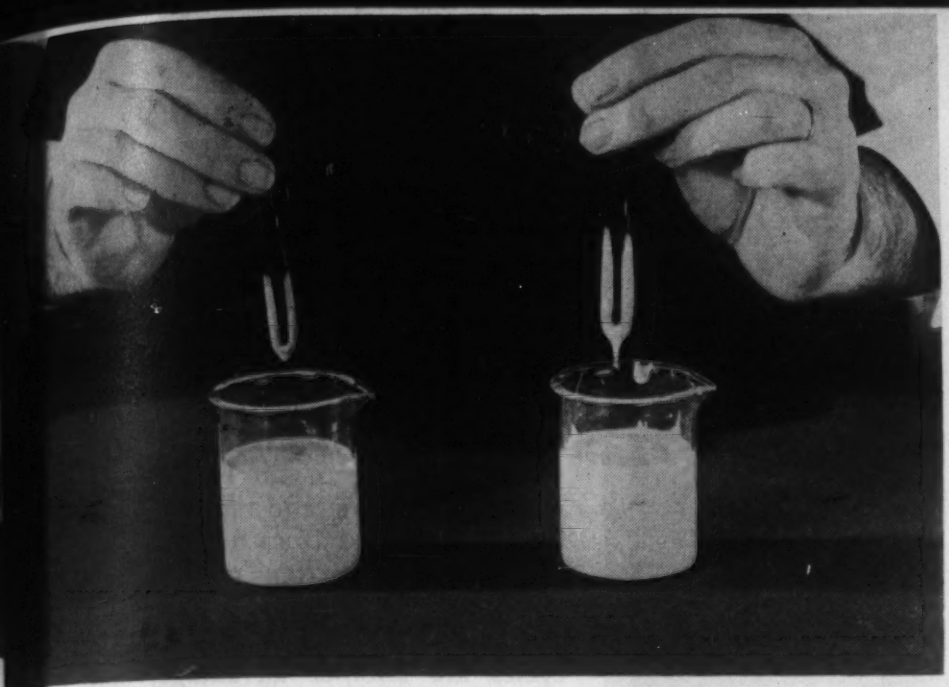
The plastisols are pourable liquids consisting of finely divided polyvinyl resins dispersed in liquid plasticizers. Various other ingredients can be added for special properties. The important thing, however, is that the resin is not dissolved in a solvent. To convert the liquid plastisol to a solid mass, it is merely heated to about 325 to 400 F, depending on the particular formulation. Since there are no volatile solvents present in the original liquid, there are no constituents to evaporate, and thick sections and coatings can be formed with no entrapped bubbles or surface imperfections. The solidification takes place by the mutual solvation of the resin and the plasticizer.

The big advantage of plastisols is that they can be processed in cheap molds, without pressure. The liquid is poured into the mold or is spread out as a coating on a surface, and heat is applied to get the solid product.

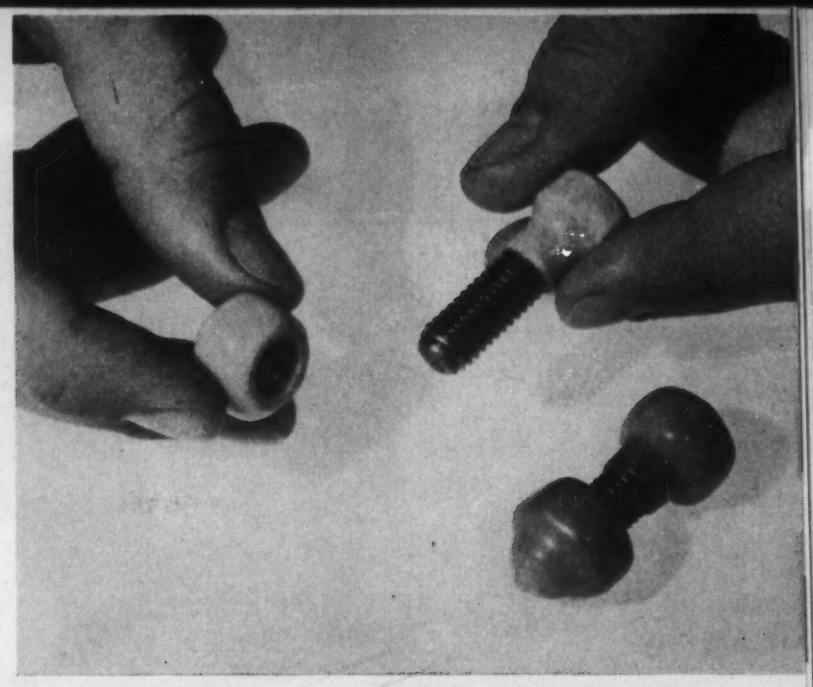
The compounding ingredients affect the strength, cost, flexibility, hardness, abrasion resistance, color, heat and light stability, oil and water sensitivity and chemical resistance of the finished plastic product. The flow properties of the liquid also depend on the ingredients. Polyvinyl chloride, copolymer polyvinyl chloride-acetate and copolymer polyvinyl chloride-vinylidene chloride and other vinyl chloride copolymer resin powders are used in various formulations.

The plasticizers are important in determining the properties of the finished product and in adjusting the viscosity of the liquid plastisol for the best forming properties. Stabilizers are used to prevent breakdown during the heating cycle and to prevent degradation of the finished product due to heat or light. The color pigments used in ordinary vinyl compounding are suitable for plastisols. Fillers reduce the cost of the compound and control the liquid flow properties.

The ingredients are mixed and then deaerated to get rid of entrapped air so that the finished product will be free of flaws. In order to set the liquid, it is only necessary to heat it to about 350 F, the fusion temperature of a typical formulation. It is important to allow enough time at temperature for the whole mass to reach the fusion point,



Dip coatings can be applied with both plastisols (left) and plastigels (right). The plastigel used here has a relatively low concentration of thickening agent. (Bakelite Div.)



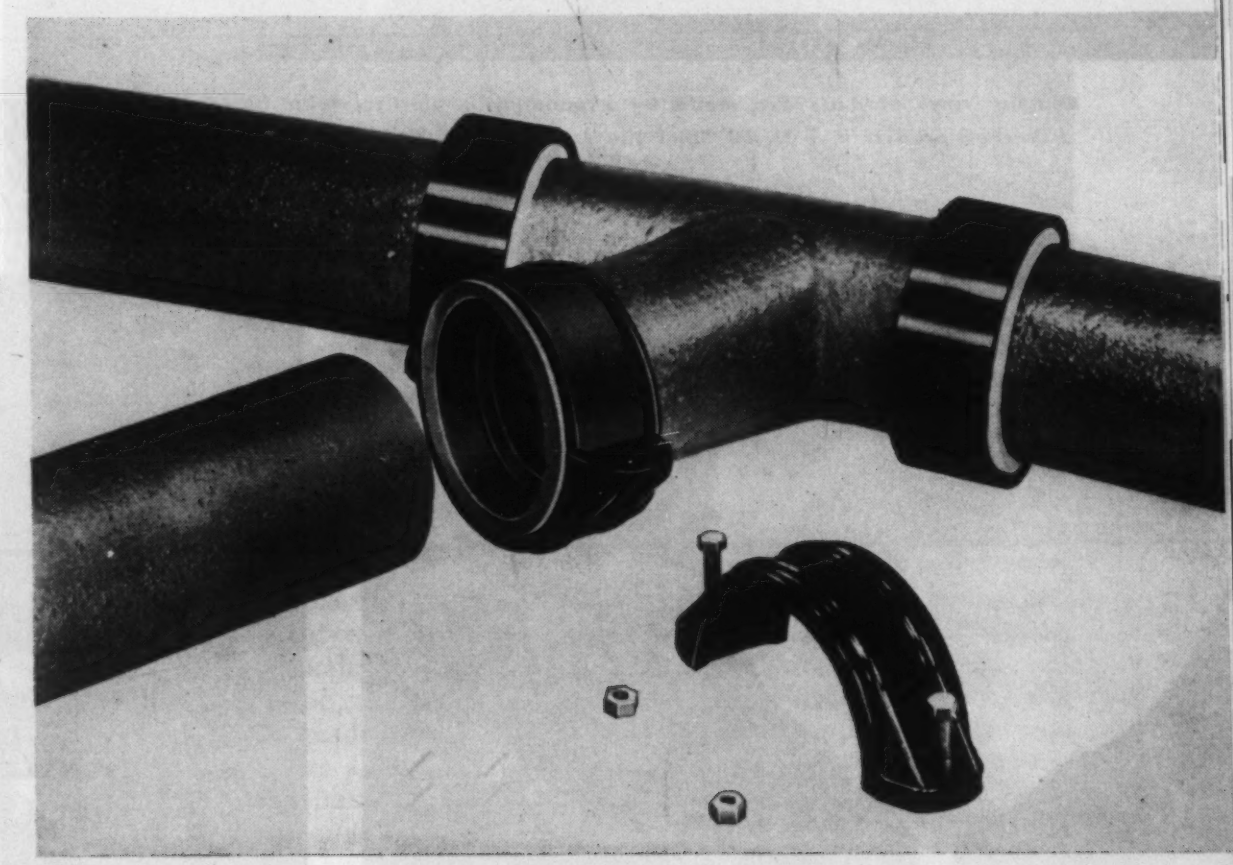
Bolts and nuts used in corrosive chemical baths are made of low carbon steel and plastisol dip coated by Steere Enterprises. (B. F. Goodrich Chemical Co.)

however. As the plastisol comes from the heating stage, it is in a plastic state. In this plastic state, the material can be marked or embossed with cold rolls and a minimum of pressure.

The plastisols can be formed in a number of ways. Coatings can be put on fabrics and papers in thicknesses up to 0.032 in. or more in one application. Films can also be cast. Parts can be dip coated up to 0.25 in. thick. Preheating parts increases the thickness attainable. Aluminum, light gage steel and plaster molds can be used to cast more massive pieces. Plastisols can also be used in slush molding. Here the liquid is poured into a mold and out again to leave a coating on the inner walls. The mold is then heated and the fused product is obtained in the form of a hollow part. Conventional molding in open and closed molds and injection molding with special equipment can also be used. With suitable machines, plastisols can be extruded. The big advantage of injection molding and extrusion is the ability to produce articles of low durometer readings. Low viscosity formulations can also be sprayed effectively. The conventional vinyl processing methods are used to print and paint plastisol products.

Plastigels

Plastigels are plastisols to which a gelling agent has been added to increase the viscosity. By varying the concentration of the gelling agent, plastigel formulations can be made that vary in consistency from dipping compounds somewhat like ketchup to molding compounds as stiff as modeling clay.

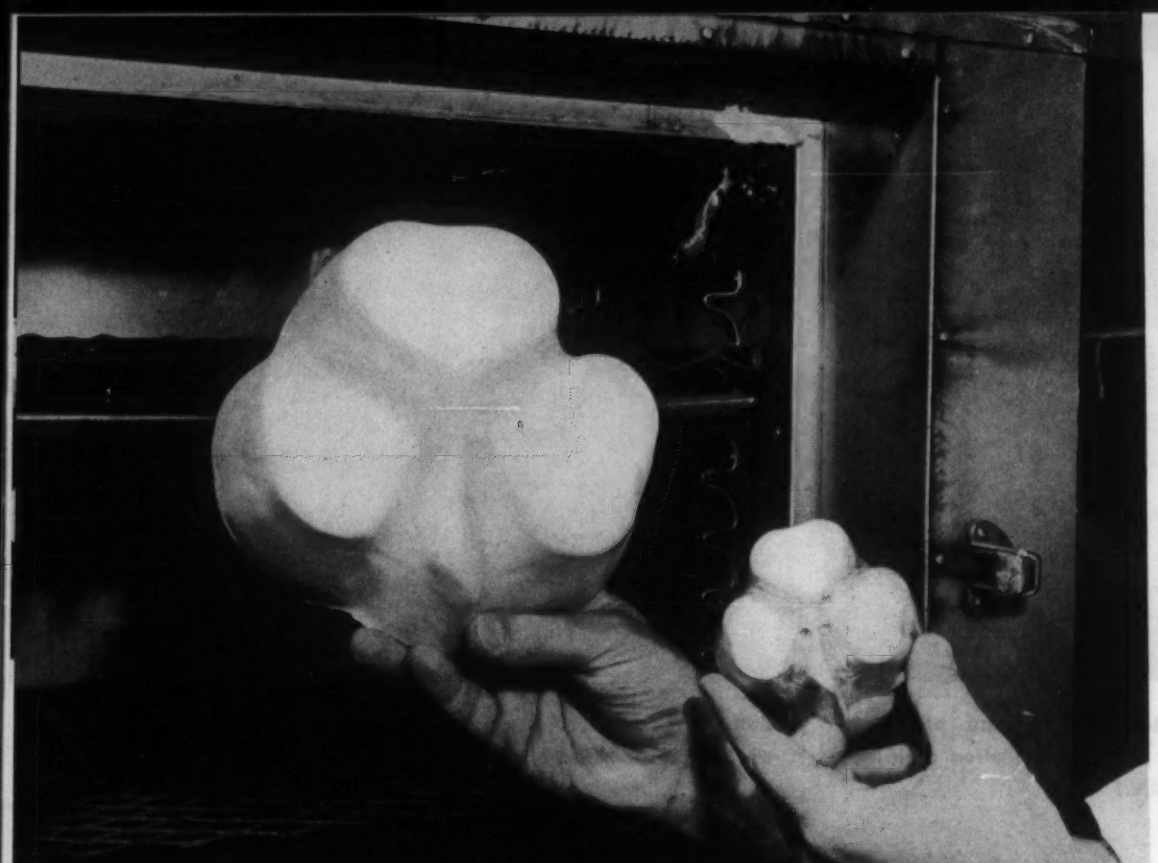


A joint for ceramic pipe is made by casting a plastisol jacket over the pipe ends. A phenolic collar screws over the threaded plastisol jacket to join the pipes. The result is a flexible, corrosion resistant joint. Robinson Clay Product Co. is the manufacturer. (B. F. Goodrich Chemical Co.)

The ingredients used in plastigel formulations are similar to those found in plastisols. Resins, plasticizers, stabilizers, pigments and fillers are compounded together. In addition, the plastigels contain the special thickening agents which convert the mixture to gels.

The forming of parts with plastigels is different from the techniques used with plastisols. In their raw state, many plastigels are relatively stiff. They can be quickly softened at room temperature by stirring or kneading, and formed by hand pressure, molds or dies into complicated shapes and fine details. After forming, these plastigels gradually stiffen again and become self-supporting. They bake to a hard, finished state in 10 to 15 min or less at 350 F without shrinking or otherwise losing their formed shapes. For example, a sound recording was stamped into a plastigel, then removed. Fused out of contact with the mold surface, the plastigel was found to have picked up and retained the groove pattern with sufficient fidelity to play a recognizable tune on a phonograph.

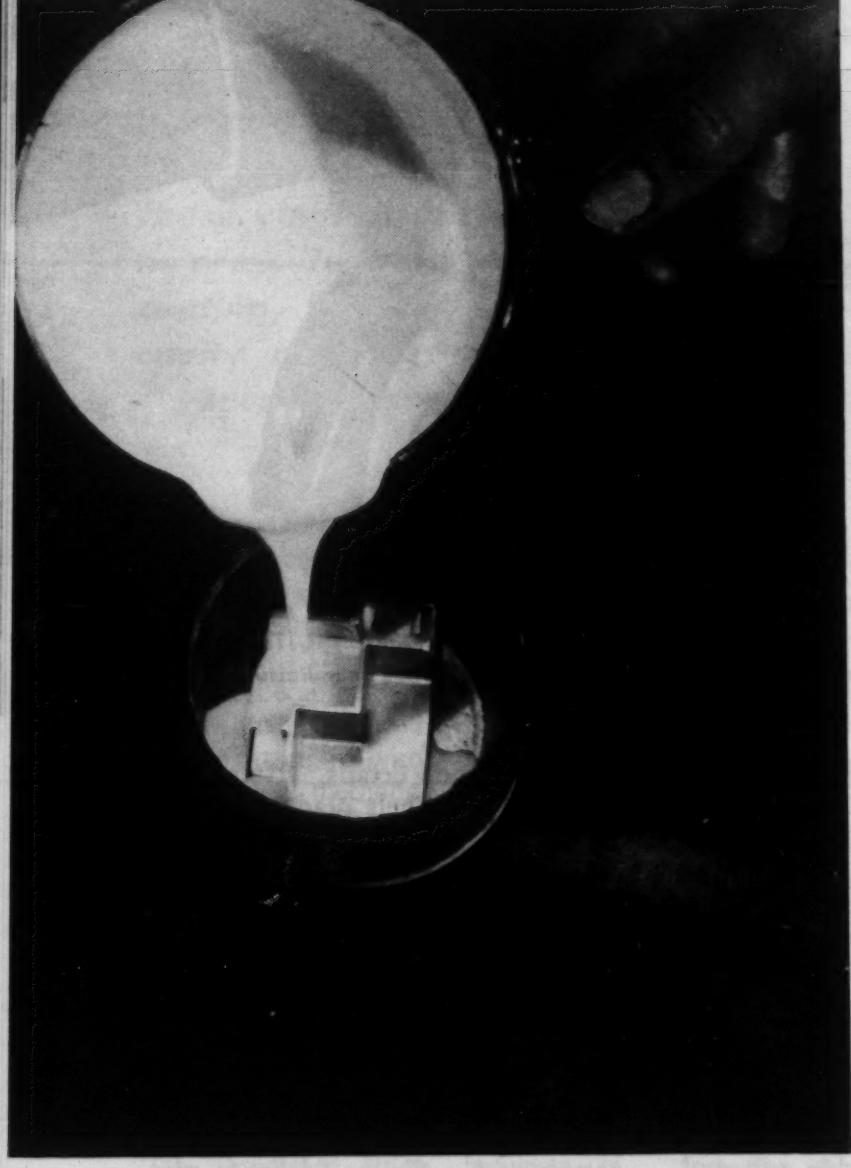
A variety of fabrication methods are used. The extrusion of plastigels



Cellular vinyl products are made by expanding a plastisol with blowing agents. The finished product is 9 to 10 times the original mold size. (United States Rubber Co.)

does not require high pressures; the extrusion dies are not difficult to design since the low pressures do not distort the extrusion shapes very much. Calendering under low pressures can be used to coat cloth, paper, felt and similar materials, or to make unsupported sheets. The unfused plastigels can be embossed easily. Molding and stamping are also promising fabricating processes. Excess material from molding and stamping can be reused, since it is not fused at this point. Fast molding cycles are another advantage, since the objects are only formed in the mold and the heating is a separate operation.

The viscosity of the plastigel varies with the use. Spreading on cloth or paper at high speed requires a relatively low viscosity. Plastigels thinned with volatile diluents spread readily, and after the mild drying required to evaporate



Plastisol molds are made by pouring the plastisol into a formed co ntainer and heating the whole assembly to the curing temperature. The positive metal pattern can then be taken out of the mold. About 50 phenolic parts or 10 to 50 polyester parts can be cast in a plastisol mold. (B. F. Goodrich Chemical Co.)

the diluent, regain their plastigel properties. Thus, the flow can be controlled to coat open-weave cloth or to prevent penetration into a porous surface. Only a low yield strength is required to prevent dripping when dip coating. The production of dip coatings is easy with plastigels, since it is not necessary to preheat the object.

Care must be taken to remove entrapped air from putty-like plastigels during processing. Air pockets are difficult to get out of a heavy mass. If a piece with entrapped air is fused directly, the air will cause surface blisters One solution to the problem is to heat the plastigel at about 225 F for a short period to remove this air. The part can then be raised safely to the fusion temperature.

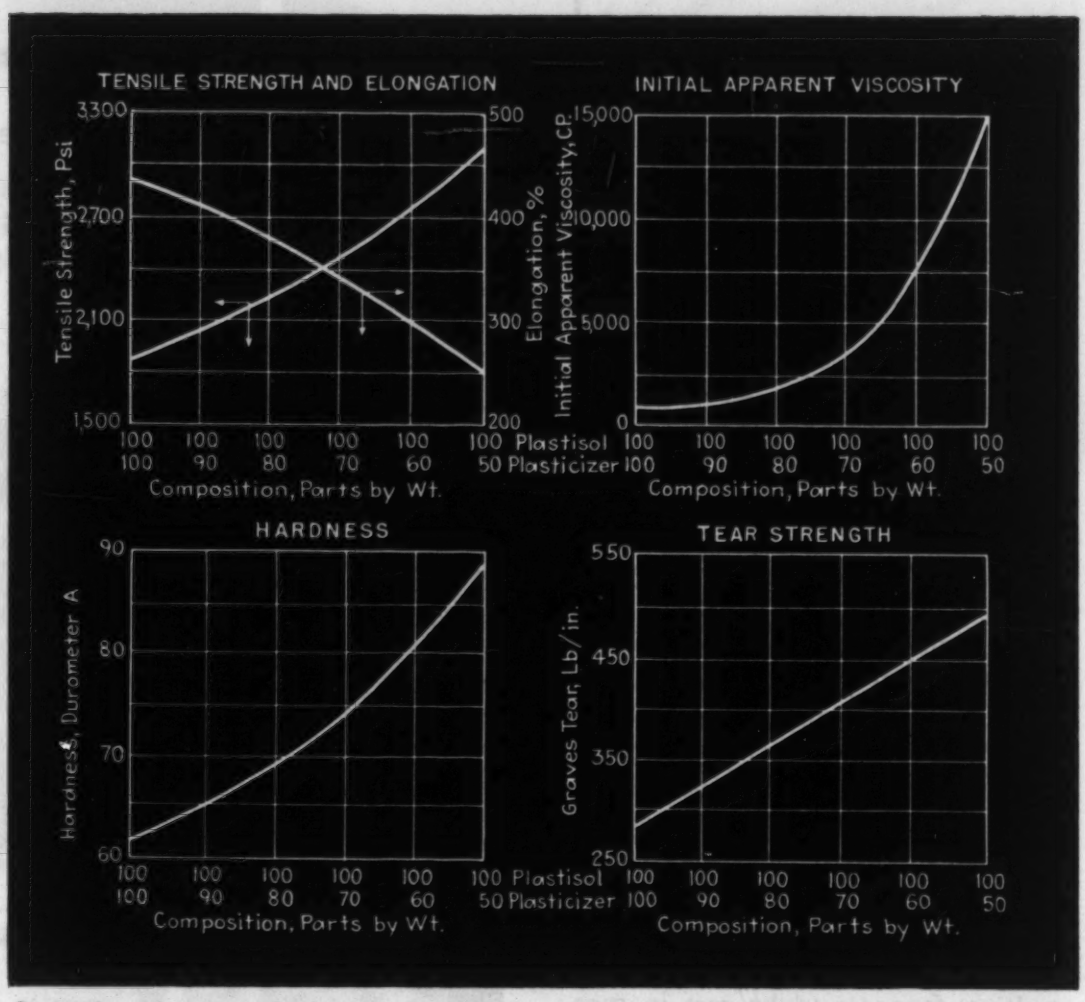
Properties

After curing, products made from plastisols and plastigels have almost the same characteristics as products made from vinyl resins by conventional fabricating methods. These characteristics include exceptional durability, resistance to tearing, abrasion, moisture, mold, oils and many chemicals. The finished product varies from a soft, rubber-like material to a relatively firm material, depending on the formulation. Tensile strengths vary from about 1500 to 4000 psi. Resistance to shock and abrasion are good. The fused material has good dielectric qualities and resists attack by most acids, bases and alcohols. Resistance is poor to ketone and esters, however. These properties all depend on the composition used, and to a large extent on the plasticizer. With some gelling agents, printing and adherence of lacquer may be problems in plastigels.

Applications

Plastisols and plastigels can be used where the characteristics of vinyls are desired and the unique processing qualities of these materials can be used to advantage.

Flexible parts can be molded from plastisols or plastigels. While the elastic recovery and creep characteristics may not be as good as with rubber compounds, the colorability, ease of fabrication and greater resistance to aging of the plastisols and plastigels are often more desirable qualities. Flame resistance can also be built into a compound. Diaphragms, bellows, grommets and



Properties of a typical plastisol. Both the cured and uncured state vary with percentage of plasticizer added. (B. F. Goodrich Chemical Co.)

gaskets are typical products. Models, flexible molds and tool handles can also be low pressure molded or dip coated. The low density and nonshattering qualities of plastigels also suggest them as replacements for ceramics in equipment to resist inorganic acids and alkalies at room temperature. Clay pipe is joined by casting a plastisol thread joint over the pipe. These joints are held together by a threaded phenolic collar to give a leak-proof joint.

Protective coatings are another field of use. Since there is no solvent evaporation, these coatings are not subject to the shrinkage or the defects found in heavy lacquer coatings. Electroplating racks are coated to protect them in corrosive plating solutions. Plastisol coatings are also used on tool handles. Low carbon steel nuts and bolts receive a protective coating by dipping in a plastisol. Through proper compounding and a special hardening treatment, these coatings can be made with a hardness in excess of 100 Durometer A. The nuts and bolts are used in or near corrosive chemical baths which attack even stainless steel, to some extent. Wire soap dishes, conveyor buckets and speedometer cables are also coated.

There are a number of electrical applications. Assemblies can often be potted in plastisols and plastigels. The choice of filler material is selected to meet the heat conductivity required. Extruded and cast insulation can also be put on wire and intricate electrical fittings. Welding leads and electric busbars are encased in this way. The desirable qualities here are toughness and abrasion resistance. The low operating temperature limits may be a drawback in some cases, however.

A special use of plastisols is in vinyl cellular materials. The plastisol is blown up to form a closed cell product which is used for flotation equipment and as heat insulation. One advantage of vinyl is that it will not support fire. In floats, it gives exceptional weather and water resistance, together with light weight and toughness.

Acknowledgments

We gratefully acknowledge the help of the following companies in preparing this article:

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The Goodyear Tire & Rubber Co.
The Society of the Plastics Industry, Inc.
The Stanley Chemical Co.
United States Rubber Co.

Materials at Work

Here is materials engineering in action . . .

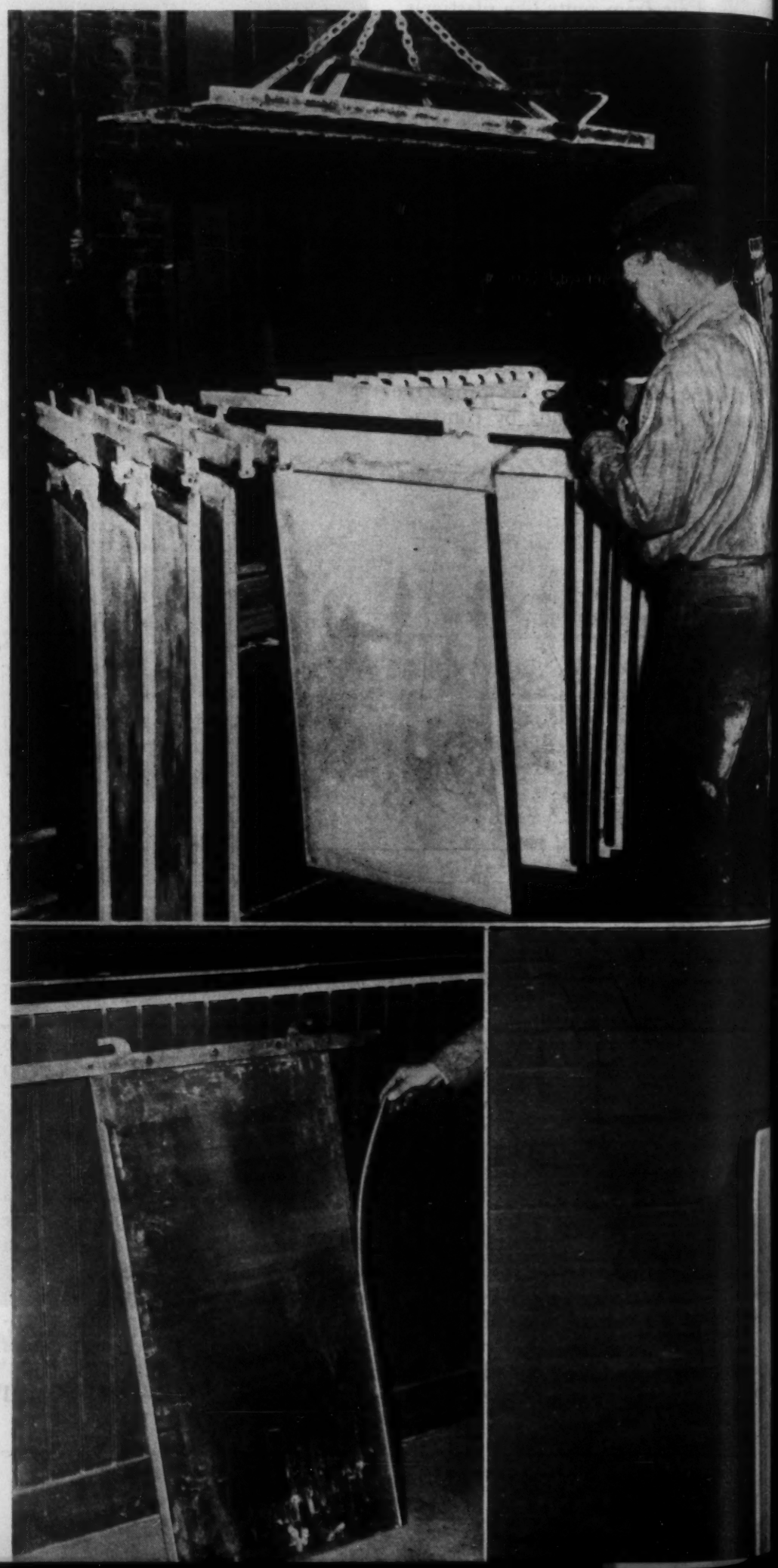
New materials in their intended uses . . .

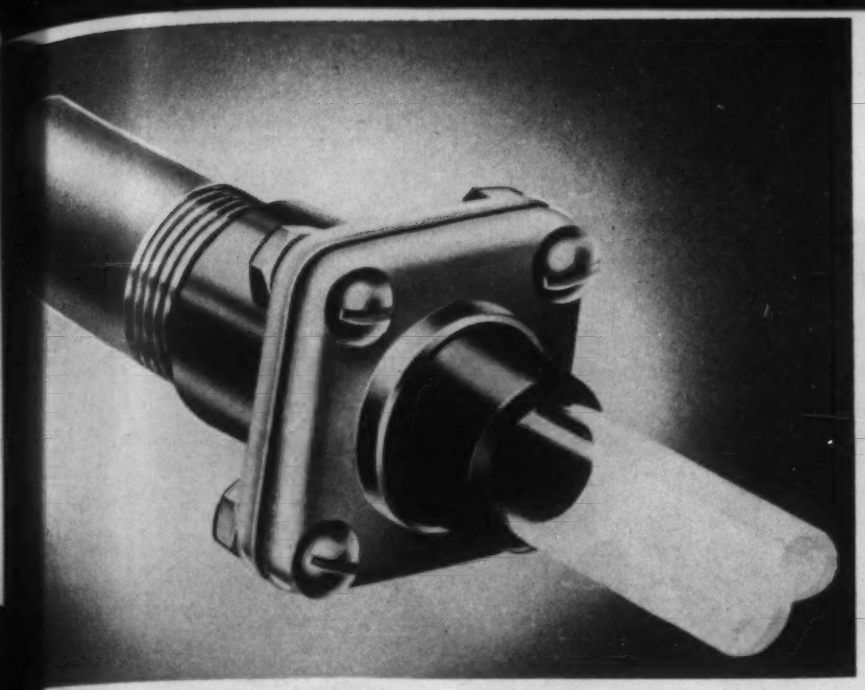
Older, basic materials in new applications . . .

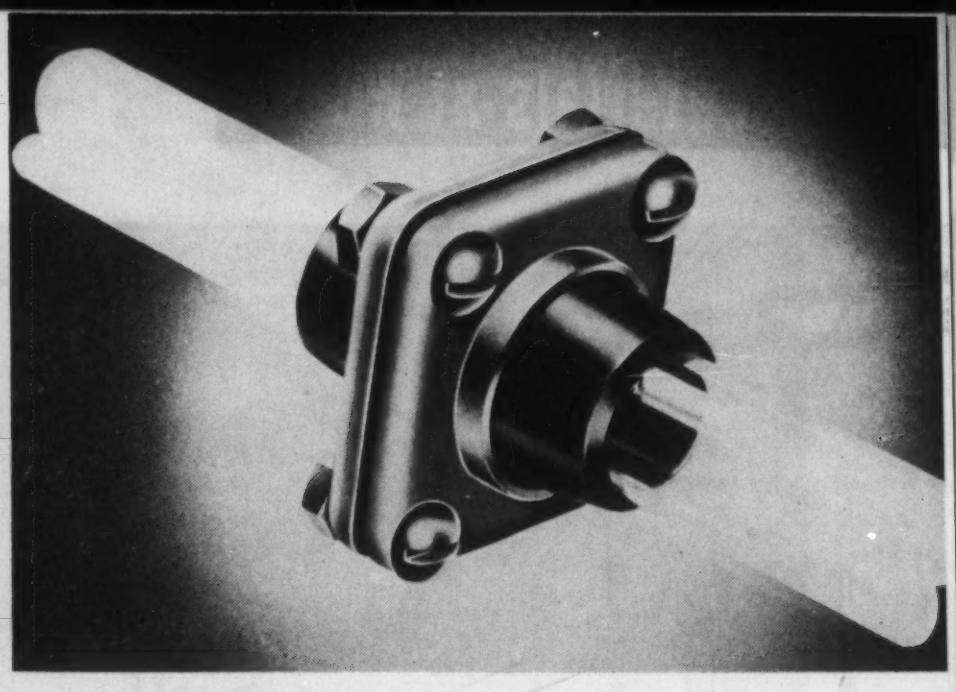
POLYETHYLENE STRIPPING SHAPES Development of an improved stripping device for aiding the removal of electrically deposited zinc from cathodes has been revealed by Anaconda Copper Mining Co. Zinc is deposited by direct current on aluminum cathodes which are suspended vertically between lead anodes in a solution of zinc sulfate. Every 24 hr these aluminum cathodes are gang-lifted by overhead electric hoists from the electrolytic cells to stripping racks where the zinc deposits are stripped from the aluminum cathodes and sent to zinc melting furnaces to be cast in marketable shapes.

To facilitate the stripping of the zinc deposits from the aluminum cathodes, it had been the practice to fit a grooved wooden stick on each vertical edge of the cathode. This separation of the zinc deposit along each vertical edge permits easy removal of the zinc from the aluminum. However, wood broke easily, and was attacked by acids and subject to swelling and distortion.

In order to improve the stripping operation, Anaconda engineers designed a channel shape with special projections which was extruded in Aeroflex (polyethylene) by Anchor Plastics Co., Inc. This material does not rot, is not attacked by acids, does not absorb water, and being flexible, will not break. The material has a certain amount of springiness which makes for a tight snap fit on the cathode. Although costing several times as much as did wood, the plastic strips have proven economical due to their long service life and easy strippability.





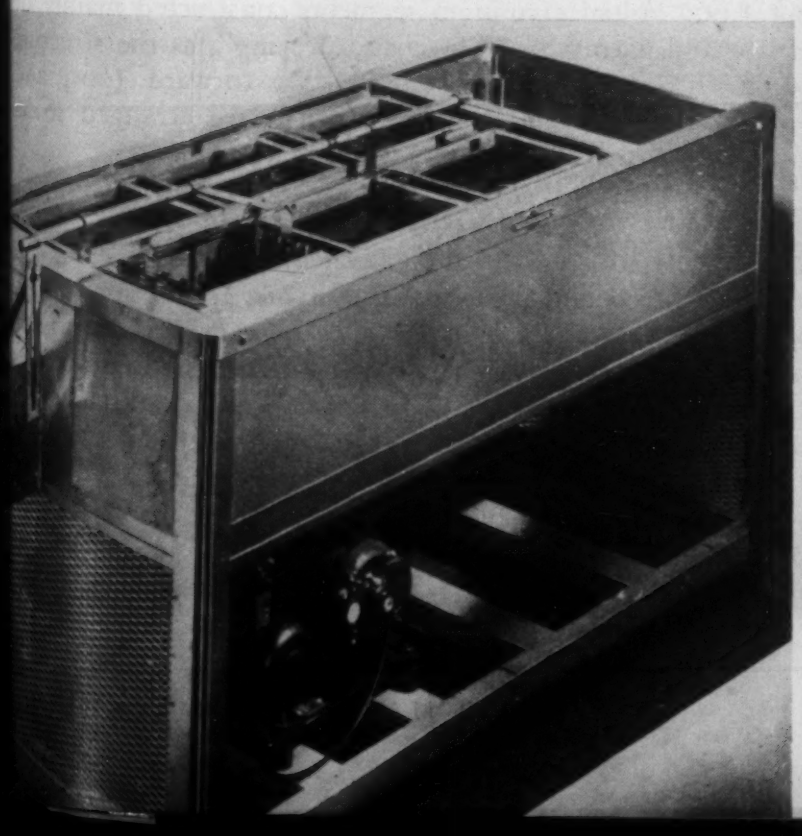


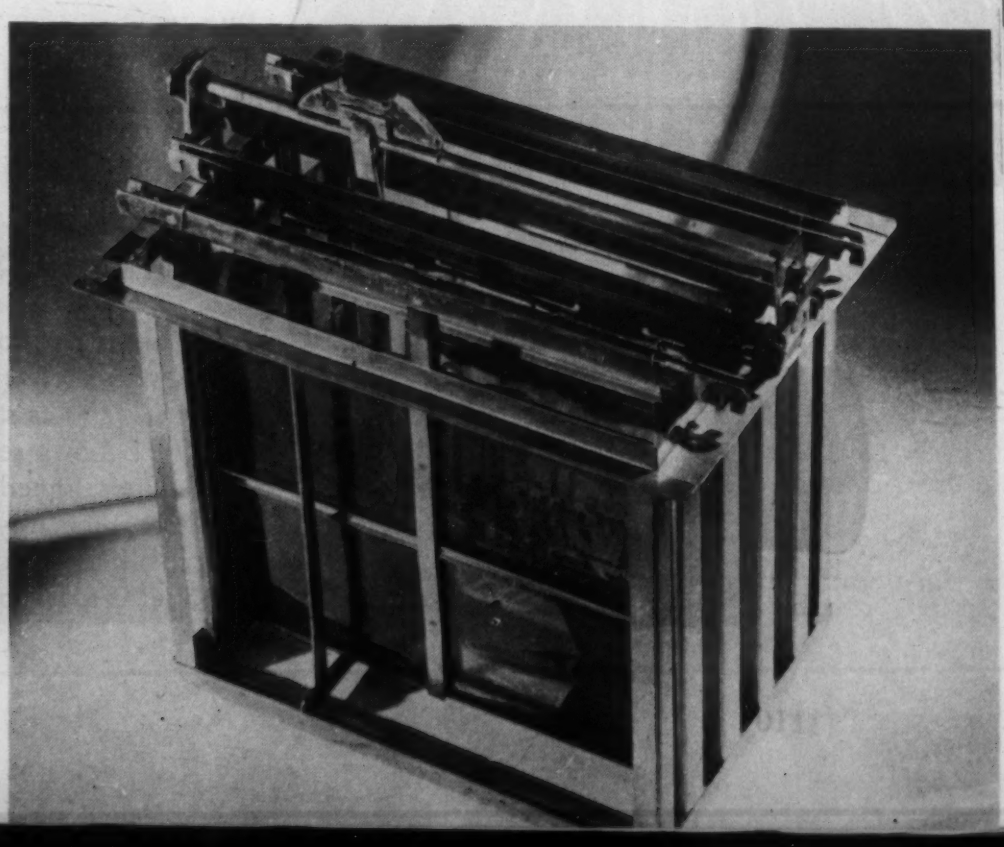
SWP BUTYRATE PIPE A complete line of SWP (Solvent Welded Pipe) pipe and reinforced fittings of virgin butyrate is now being made by Elmer E. Mills Plastics Corp. in sizes ranging from ½ through 4 in., with larger sizes to be produced in the near future. The fittings are quickly and permanently joined to the pipe by means of a solvent type cement, which produces a homogeneous bond.

Since threading of butyrate pipe is not recommended, the outside diameter of SWP differs from that of standard steel pipe to the extent that conventional pipe dies cannot be used. This o.d. sizing has been adopted by the Thermoplastic Pipe Standards Assn. However, the rate of flow through SWP is equal to or greater than the flow through standard steel pipe of the same nominal size. Several schedules of SWP will be produced to meet various pressure requirements. In addition to the usual ells, tees, laterals and couplings, a flange union is available for use when the line is to be disconnected. For joining the plastic pipe to standard steel pipe, a compact, rugged, leakproof flange adaptor is utilized.

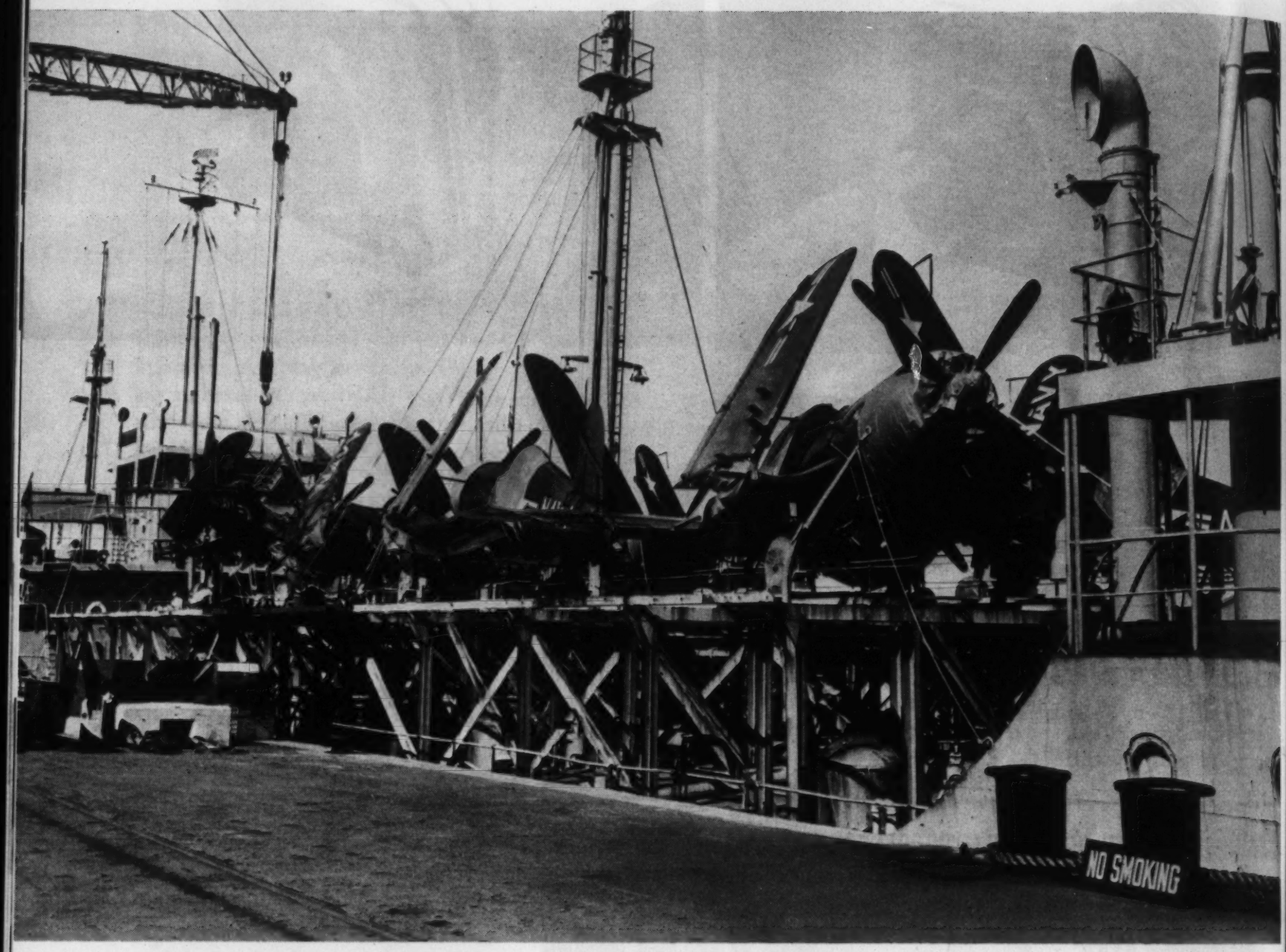
STAINLESS STEEL COLOR FILM PROCESSOR Two types of stainless steel—each selected for a specific corrosion resisting task—highlight construction of a new color-film processing machine. This photographic unit, developed and patented by Newman-Schmidt Studios of Pittsburgh, maintains improved controls over critical factors: temperature, agitation, and protection against corrosion. The machine is built entirely of stainless steel except for the motors, reduction gear box, refrigeration unit and lower enclosure.

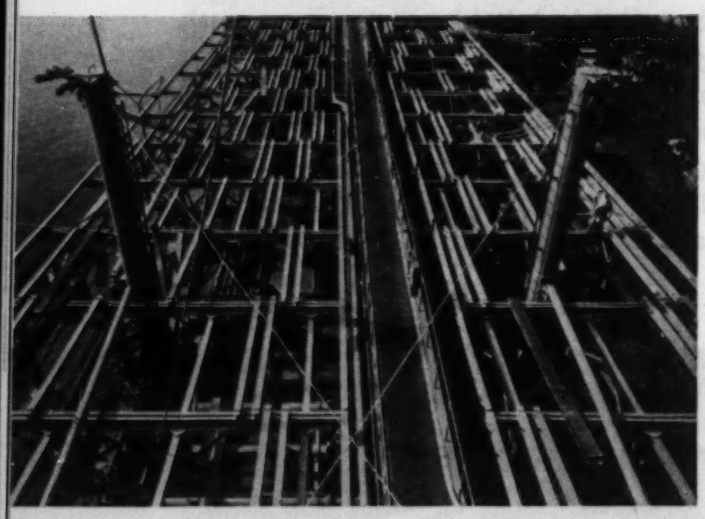
Basically, the processing machine is composed of (1) a rectangular, double-walled tank holder containing a wash tank and six 3½-gal removable solution tanks and (2) a special processing cage or several cages, equipped with agitator vanes, for holding standard size film handlers. The outer walls and other external parts of the machine are made of 18:8 Type 302 stainless steel selected for its strength, workability and corrosion resistant properties. Type 317 stainless steel, containing molybednum for added protection against corrosion, is used for the cage, tanks, inner walls and other parts that are exposed to the photographic solutions. These parts offer complete protection against metallic contamination resulting from corrosive attack on metal parts by acetic acid in black-and-white processing or potassium ferricyanide in color processing.



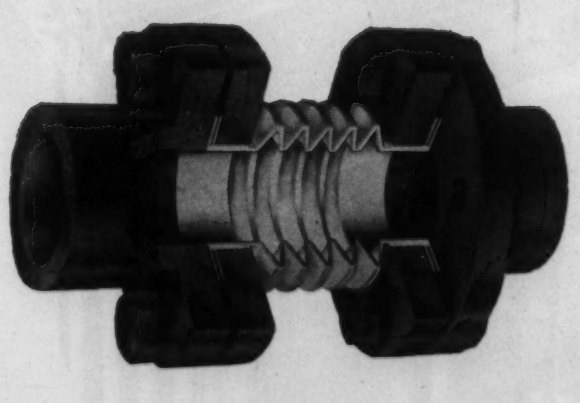


Materials at Work



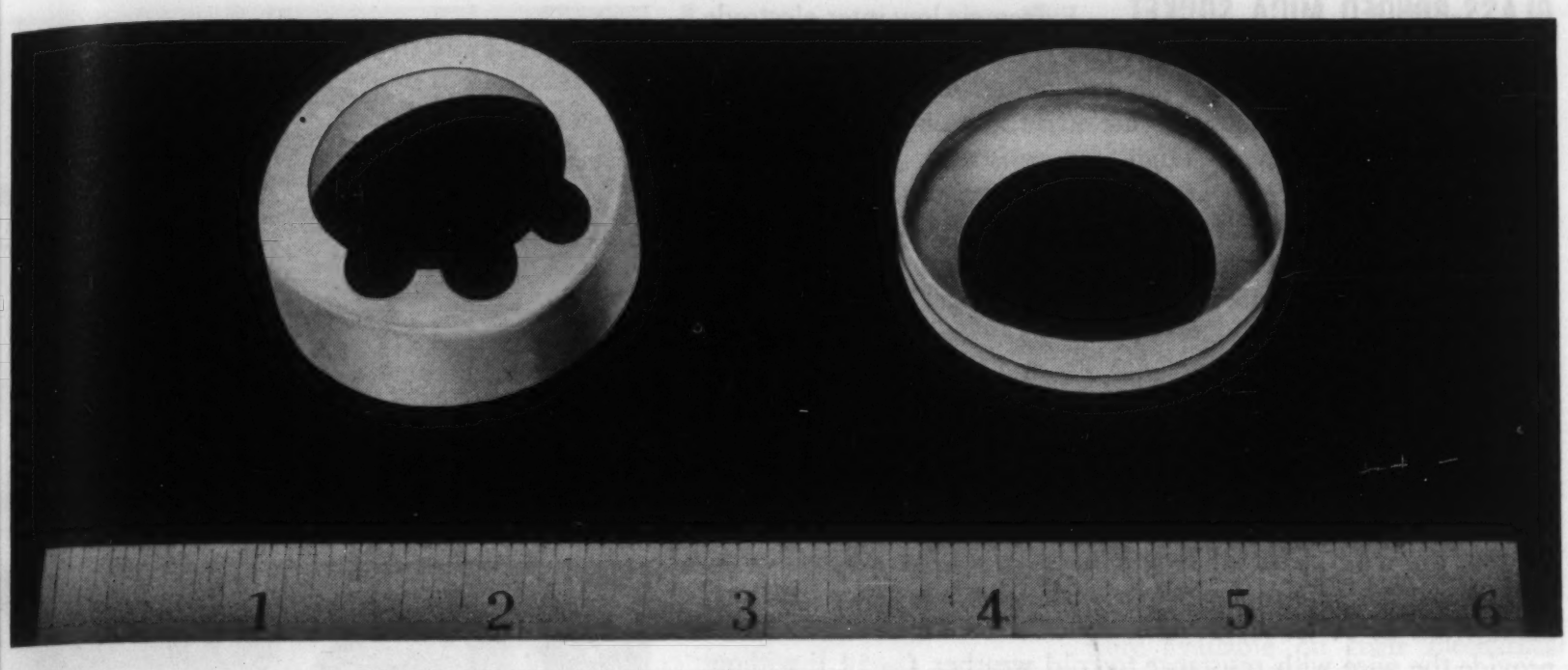


ALUMINUM CARGO DECKS Aluminum is now enabling some U. S. tankers to serve as both tankers and aircraft carriers. All-aluminum portable structure erected on the main deck provides 12,000 sq ft of additional cargo space on tankers of the Military Sea Transportation Service. On the USNS Mission San Diego, a standard T-2 type tanker, 150 inverted steel cups represent the only permanent feature of the decking. All other parts—stanchions, support brackets, deck beams, and movable longitudinal struts—are aluminum. The entire structure represents about 1,000 bolted aluminum segments constructed mainly of aluminum tubing, plate and extrusions. "Mechano decking", as the structure is sometimes called, is divided into four sections, two forward (port and starboard) and two aft, also port and starboard. These are arranged so as not to interfere with use of the ship's normal equipment.



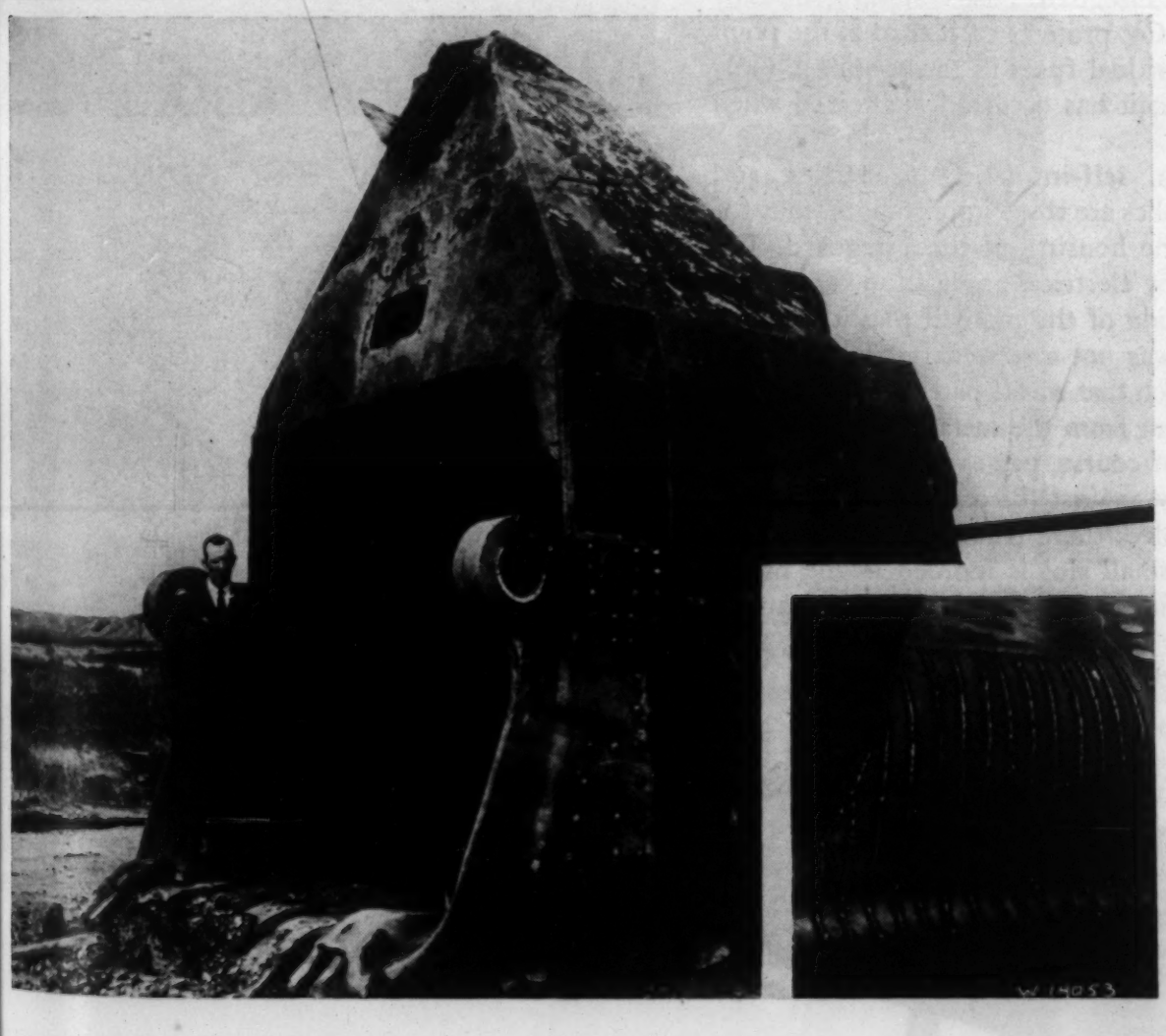
TEFLON BELLOWS CONNECTOR Fabricated of chemically inert Teflon, the new John Crane bellows type connector has many pipe line applications where vibration, expansion and electrolysis exist in the handling of corrosive liquids or gases and solvents. The connector is electrically non-conductive, flexible even at —94 F and as strong as 480 F as at 70 F, according to the manufacturer.

The bellows serve as a vibration dampener as well as an expansion joint, connect misaligned couplings and insulate flanges electrically. End flanges of the joint are French-type envelope gaskets made integral with the joint for easy assembly between companion flanges and a tight, leak-proof seal on installation. The unit is made by the Crane Packing Co.



NYLON MOTOR INSULATING SHELLS A special drawing grade of nylon strip supplied by The Polymer Corp. is being used to draw and form insulating shells for small type servo-motors. Atco Electronics Corp. has perfected a special method of drawing the shells on a production basis. The specific material used is standard FM10001 nylon strip, 0.015 in. thick by 2 in. wide.

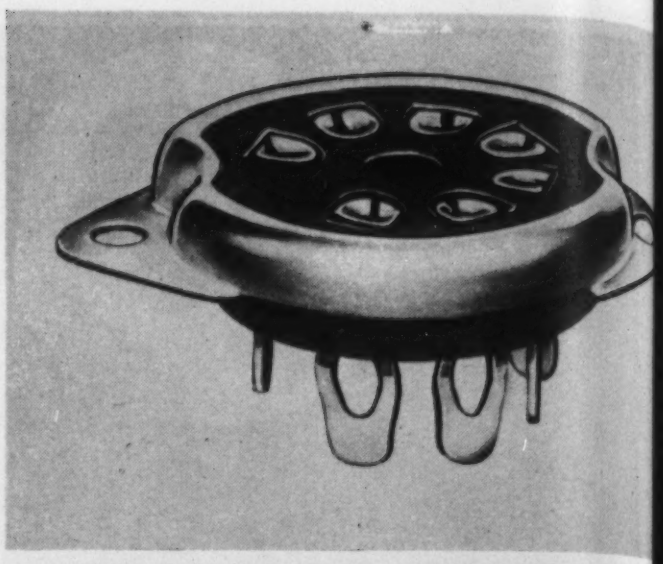
Nylon has been found to have a number of advantages over previous materials in the production of these servo-shells. Its toughness permits forming without fracturing. This quality also prevents damage and causes fewer rejects in assembly. It will not support fungus growth and, therefore, needs no further treatment. It meets the specifications for operation at 221 F, required of Class A insulation. It will remain form stable for higher intermittent temperatures, such as those encountered in temporary overload or with hot impregnating compounds.



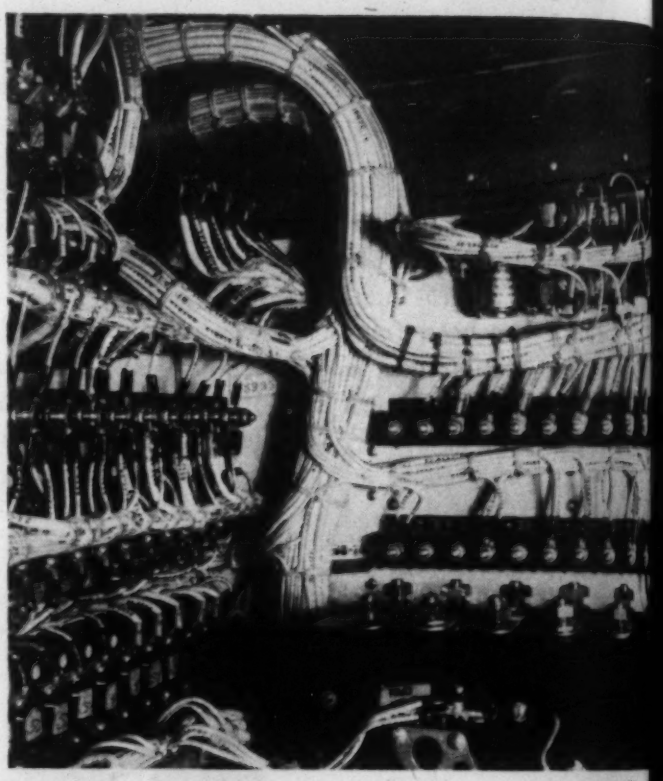
HARD - SURFACED BUCKET TIPS The capacity of this all-welded steel bucket used in strip mining is 35 cu yd. The lip and teeth are cast manganese steel, riveted to the fabricated body. As further protection against the scouring action of rock, earth and coal, the underside of the lip is reinforced with a series of 16 parallel beads of a coated tubular arc welding electrode high in carbides of tungsten, chromium, vanadium and molybdenum (Faceweld No. 12). It is furnished by Lincoln Electric Co. Operators claim the spaces between the beads fill up with excavated material, resulting in equivalent wear to that of a fully coated surface. The beads are 2½ in. apart, extending across the bottom of the lip and a third of the way up the sides.

Materials at Work

GLASS-BONDED MICA SOCKET Extremely low inter-electrode capacitance is the selling point of this socket, injection molded of glass-bonded mica. The high dimensional stability of the material permits a minimum amount of dielectric to be used so that air is utilized as the insulator. High arc resistance, high dielectric strength and non-porosity are other characteristics. There is practically no change in electrical properties up to 700 F. High thermal shock resistance of the material prevents harm to the body in soldering. The sockets are made by the Mycalex Tube Socket Corp.

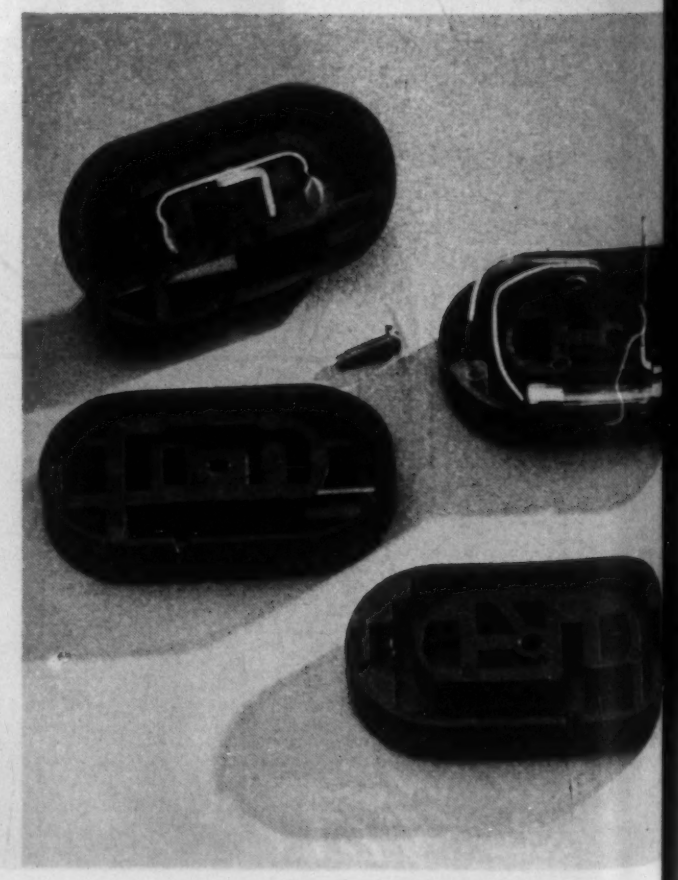


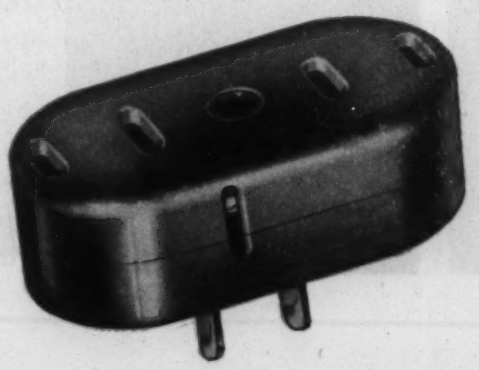
PLASTIC INSULATION A new aircraft wire developed to meet electronic wiring applications for military aircraft features a polyvinyl chloride plastic primary insulation and a nylon jacket extruded on the wire. A product of Surprenant Manufacturing Co., Boston, the wire meets all requirements of Military Specification MIL-W-5274A. The polyvinyl chloride plastic primary covering, made from B. F. Goodrich Chemical Co.'s Geon resin, helps to provide the wire with resistance to cold weather (—54 F without cracking), oil, grease, fungus, abrasion and flame. Vinyl is self-extinguishing when the source of flame is removed. The nylon jacket provides additional protection against these hazards. One requirement for MIL-W-5274A, Types I and II wire primary insulation, prior to the application of the outer protective coating, is that it shall be capable of withstanding without failure a minimum of 5000 v a.c. at 60 cycles rms. Type II wire has to be capable of withstanding 12,000 v rms without failure. Glass fiber braid is applied over the primary insulation of Types II and III wires, and the secondary insulation over the glass is also of polyvinyl chloride.



PHENOLIC FUSE PLUG The Fireguard Fuse Coupling made by the F. H. Smith Manufacturing Co. protects each cord at the point it plugs into the circuit by individual fuses in the coupling. Only the cord on which the short circuit has occurred is affected when a fuse blows.

The high dielectric strength, self-insulating properties, and the moldability of Durez phenolics are three important reasons for its selection as a material for the housing of the Fireguard. The importance of the first two in any electrical application is obvious. The intricate design on the inside of the molded plastic housing shows clearly why moldability was not a secondary consideration. The design of the housing is such that metal parts are held firmly in place to give a complete circuit from the metal prongs through to the cord itself. The current, of course, passes through the small fuse, which must be held tightly against the metal. Once the two parts of the housing are assembled, there is no need to take them apart when changing fuses. A small slot is molded in the prong side of the housing, and the blown fuse can be removed and a new one inserted through this opening. Hauser Products, Inc. molds the parts for the two-piece housing.

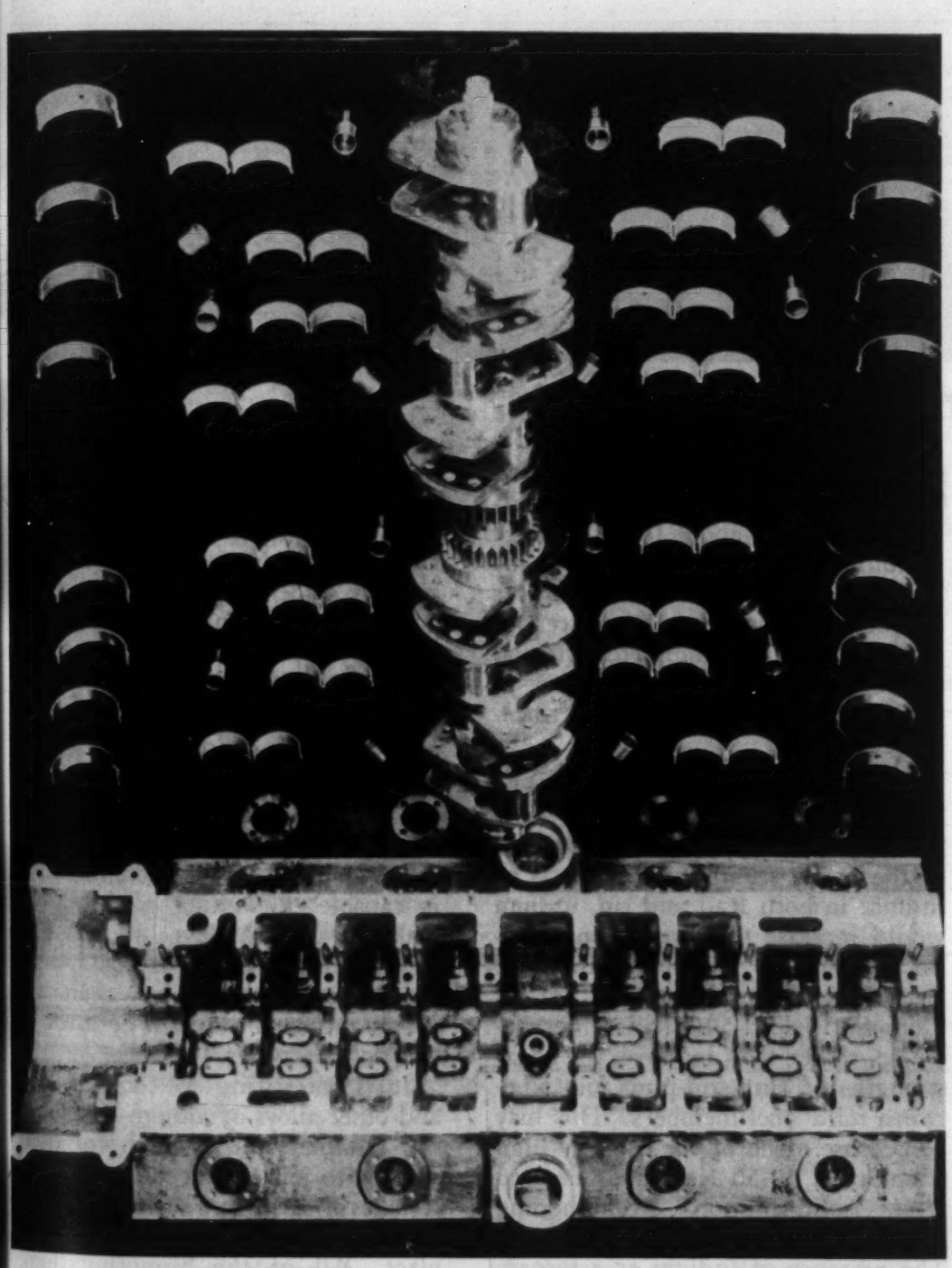




Indium Alloys Finding Important Commercial Uses

by R. I. JAFFEE and S. MARGUERITE WEISS, Battelle Memorial Institute

The special properties gained by alloying indium with lead, tin, cadmium or bismuth are put to good use in bearings, solders and glass sealing alloys.



With extremely small cylinders and a stroke of less than 2 in., a British racing car motor can be run at up to 12,000 rpm. The bearings are made by Vandervell Products Ltd., with a steel backing strip, a copper-lead alloy layer to give good fatigue resistance, and a diffused indium coating to give a low coefficient of friction, resistance to corrosion and anti-seizure properties. (Consolidated Mining and Smelting Co. of Canada Ltd.)

● ALLOYS OF INDIUM with lead, tin, cadmium and bismuth are used in bearings, solders and glass wetting materials. These applications are highly specialized but important. Despite the recognized industrial position of indium alloys, very little data were available on their mechanical properties until an investigation was undertaken at Battelle Memorial Institute recently.

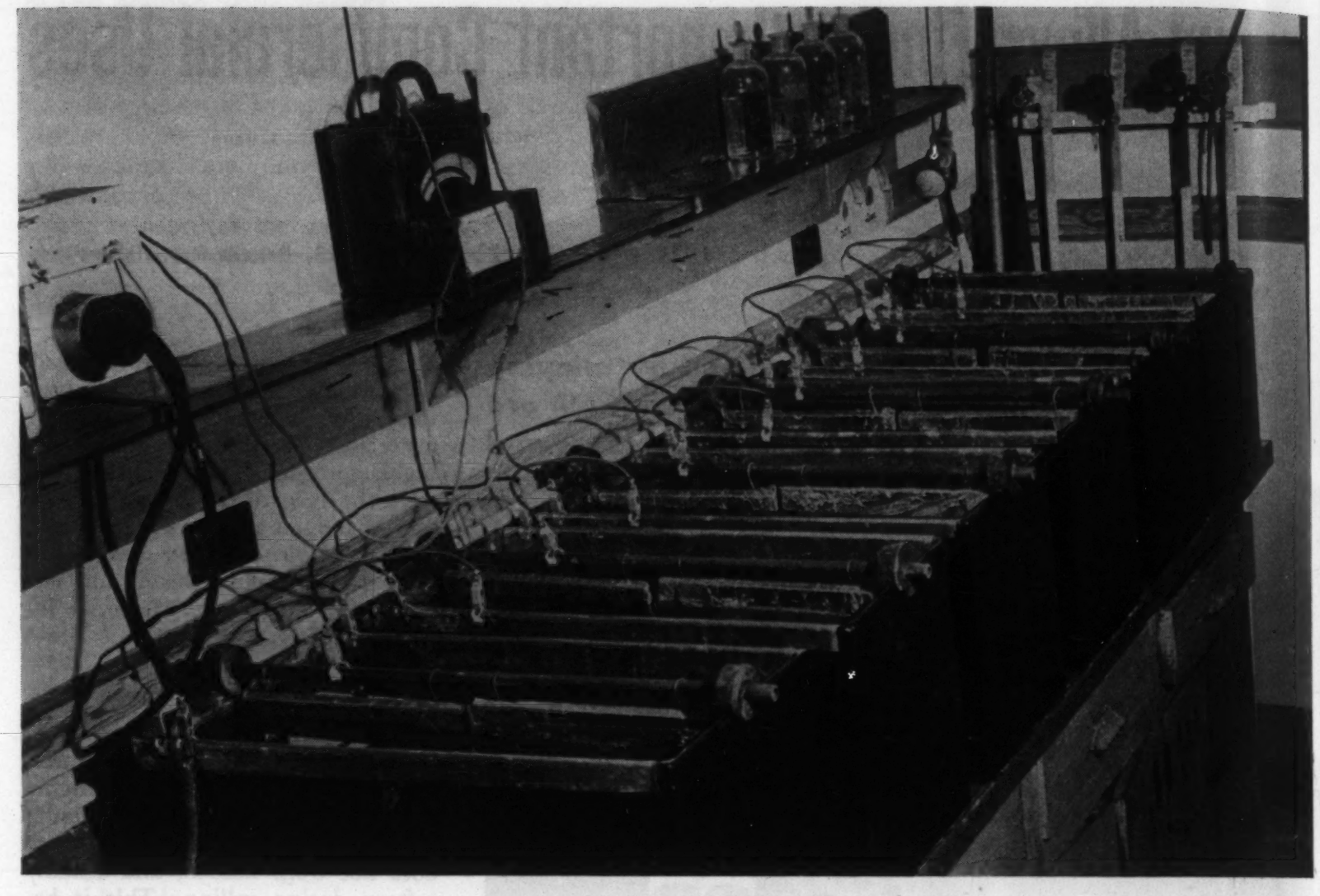
Properties

Indium is a silvery white, extremely soft metal. It is the softest metal that is stable in air. It is a highly plastic metal, and deforms under compression almost infinitely. Indium does not work harden, and actually softens during rolling. This is because the recrystallization point is well below room temperature.

The commercial value of indium lies in its alloys. The alloys with the closely related metals lead, tin, cadmium and bismuth are the most important. Indium alloys are not used where strength and high melting point are essential. However, their melting points and strengths should be high enough for the application in which they are used. The indium-lead alloys have higher melting points than any of the others. Thus, in applications such as solder, they would have a clear advantage in useful temperature range. Also, the indium-lead alloys are the hardest and strongest over most of the range of alloy content.

In the indium rich alloy region, bismuth is the most effective hardener, followed by cadmium, and then by lead. These effects were found in the indium solid solution region. Tin, which has the least room-temperature solubility in indium, has the mildest strengthening and hardening effects.

Indium in solid solution is most effective in hardening tin. It is somewhat less effective in hardening lead, but since the solubility of indium in lead is so much greater, the



A semi-commercial electrolytic indium refining plant.

maximum hardness and strength attained in the lead-indium solid solution are somewhat greater. Indium is practically insoluble in cadmium or bismuth, and it has no hardening effect on either of these metals.

Bearings

The chief application of indium has been in aircraft bearings. In the Pratt and Whitney bearing indium is plated and diffused on a steel-backed bearing which had previously been plated with a layer of silver and then lead. After diffusion (500 hr at 302 F), the concentration of indium at the surface is about 16% indium. This corresponds to a solid solution alloy of indium in lead. The improved strength and hardness of the lead-indium alloy surface do not account for the desirable bearing performance obtained with this bearing. The indium is used principally to improve corrosion resistance against organic acids in lubricating oils. However, it is probably true that the enhanced mechanical properties of the indium-lead layer do not detract from the bearing properties.

Indium diffused into a steel backed cadmium-alloy bearing improves corrosion resistance without impairing fatigue resistance. Here, after diffusion, there is about 0.4% average indium content in the cadmium-alloy bearing. This amount of indium does not detract much from the strength of cadmium. Less complete diffusion would result in a major decrease in strength, and, perhaps, in performance.

Solders

It would be expected that, because of the major strengthening effects of indium in both lead and tin, indium would increase the strength of lead-tin soft solders. Such is not the case. Additions of 10, 25 and 50% of indium to 50 lead-50% tin solder decrease, rather than increase, the shear strengths of ring-and-plug joints between mild steel members. This may be because much of the usefully high strength of 50-50 lead-tin is derived from solid-solution strengthening effects of lead and tin in each other. The presence of indium as a ternary component may reduce the mutual intersolubility of lead and tin. However, the ternary indium-lead-tin soft solders have improved resistance to alkalies, the purpose for which they were developed.

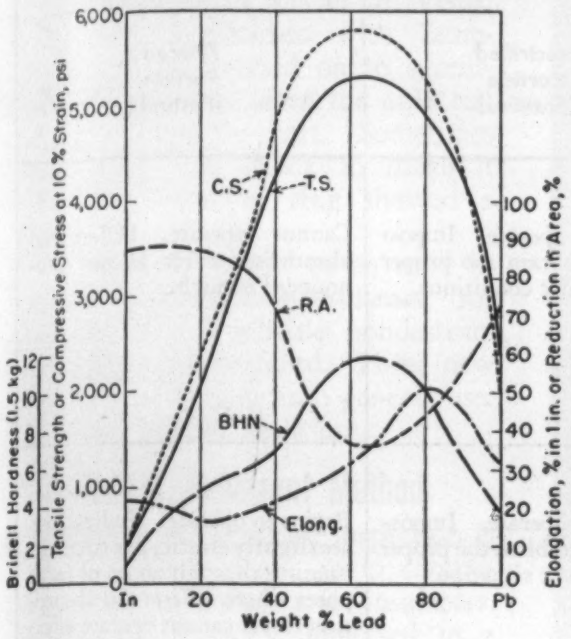
Indium additions of 1 and 2% to a lead-base 3% silver soft solder increase strength markedly. A proprietary solder of the same type with 5% indium also has high strength.

Glass Sealing Alloys

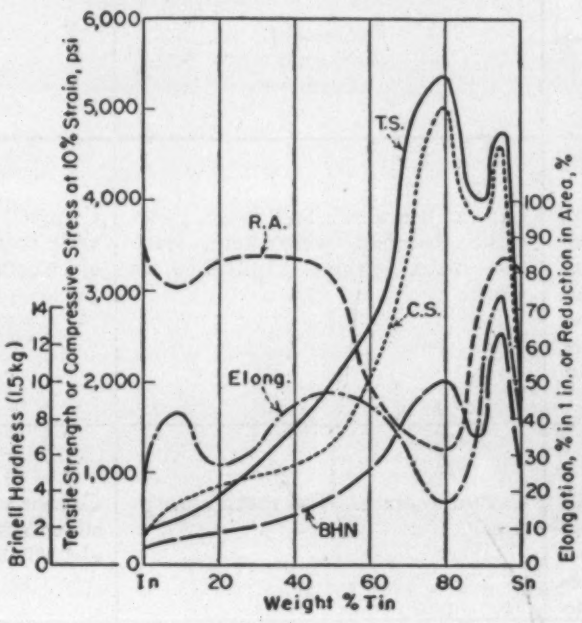
A very useful present application of indium is in the form of a proprietary alloy marketed by the Cerro de Pasco Corp. under the name Cerroseal 35. This contains about equal amounts of tin and indium. It is capable of wetting glass and of making glass-to-glass or glass-to-metal seals. The alloy is first applied to preheated glass by swabbing. Joints and seals can then be made in conventional ways.

It is interesting to compare this and other alloys of indium with lead, tin, cadmium and bismuth for their abilities to join nonmetallic materials. It takes a surprisingly small concentration of indium to cause wetting of glass. All of the bismuth-indium, cadmium-indium and indium-lead which contained 5% or more indium can be applied to glass and used for making joints. It takes more indium, however, to promote wetting of glass

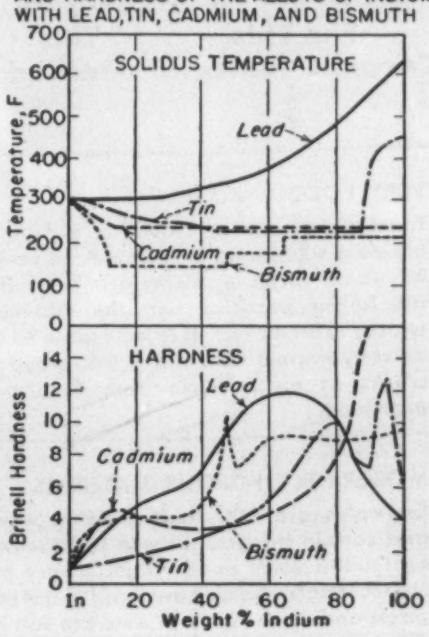
MECHANICAL PROPERTIES OF INDIUM-LEAD ALLOYS



MECHANICAL PROPERTIES OF INDIUM-TIN ALLOYS



COMPARISON OF SOLIDUS TEMPERATURES AND HARDNESS OF THE ALLOYS OF INDIUM WITH LEAD, TIN, CADMIUM, AND BISMUTH

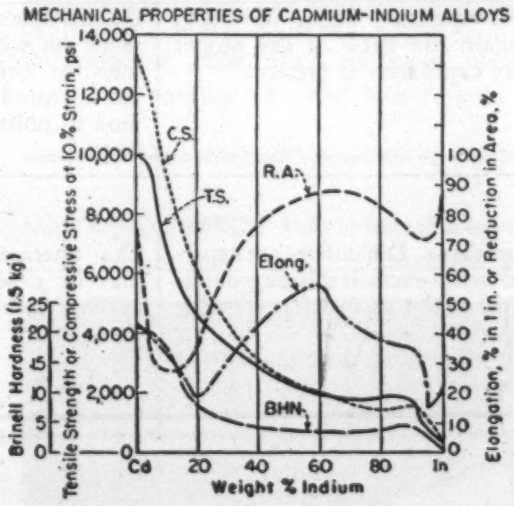


by indium-tin alloys. A 40% indium alloy in tin will wet, but a 20% alloy will not. The minimum indium content in lead that will promote wetting may be as low as 0.5%.

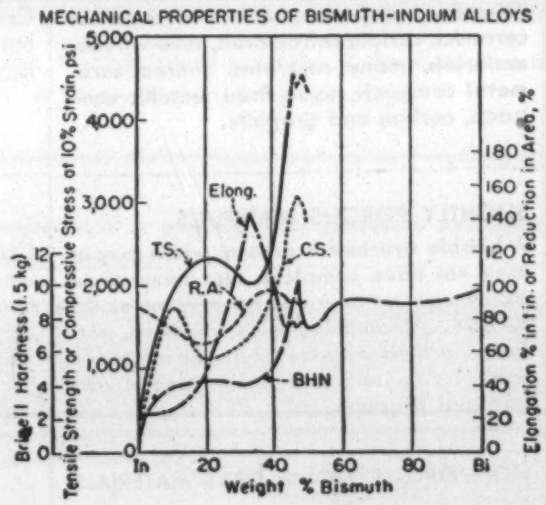
The higher indium content glass sealing alloys have one undeniable advantage over those which were very lean in indium. That is their ease of spreading on glass. When the indium content is low, there is only a small temperature gap, just below the liquidus temperature, where good spreadability of the molten alloy on glass is obtained. At higher concentrations, around 50% or more indium, considerable leeway in temperature is permissible. Shear strengths of glass-to-glass seals vary from 350 to 1000 psi.

It would appear that the indium-lead alloys, with their higher melting points, would have certain advantages as glass sealing alloys, since temperature is a critical factor in many glass-to-metal seal applications. Compared with the 50 indium-50% tin glass sealing alloy, for example, a 50 lead-50% indium alloy would have an advantage of about 140 F. However, the vacuum tightness of seals made with an indium-tin eutectic alloy is considerably better than that of the indium-lead alloy. Resistance to cyclic thermal stresses set up by alternately heating and cooling between 212 F and —58 F is excellent for both types of vacuum seals.

MECHANICAL PROPERTIES OF CADMIUM-INDIUM ALLOYS



MECHANICAL PROPERTIES OF BISMUTH-INDIUM ALLOYS



Mechanical Properties of Pure Metals*

Property	Indium	Lead	Tin	Cadmium	Bismuth
Brinell Hardness	0.9	3.9	5.2	20.7	9.6
Tensile Strength, Psi	380	2410	1770	10,000	—
Elongation, % 1 In.	22	32	37	42	—
Reduction in Area, %	87	74	81	76	—
Compressive Strength**, Psi	310	2050	2070	13,000	—
Modulus of Elasticity, Psi	1.57×10^6	—	—	—	—

** Tests conducted on the metals as-annealed one week at 230 to 266 F*
*** True compressive stress at 10% true strain.*

Acknowledgment

The authors acknowledge with thanks the permission of the Consolidated Mining and Smelting Co. of Canada, Ltd., to publish this work.

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For This Ceramic Material ↓ / This Method →	Fluorescent Penetrant (Zyglo)	Electrified Particle (Statiflux)	Filtered Particle (Partex)
VERY POROUS MATERIALS **The type of porosity found in a 60-mesh grinding wheel and in certain fired ceramics where large particles are bonded to still larger particles, with the subtended spaces left empty. It is impossible to universally inspect ceramics in this group for cracks as such. Sonic methods appear promising.**	Cannot operate. Too much penetrant absorbed everywhere, with too little genuine capillarity at work.	Cannot operate. Impossible to obtain the proper electrostatic conditions.	Cannot operate. Differential absorbtion effect is not pronounced enough.
MODERATELY POROUS MATERIALS **Examples are 100-mesh grinding wheels and certain refractories with particles and subtended voids smaller than in very porous materials. Some powdered metal compacts and some types of concrete fall into this category.**	Cannot operate. Too much absorption.	Cannot operate. Impossible to establish the proper electrostatic situation.	Begins to operate. Indications are slightly erratic, due to cracks running through zones of large pores where differential absorption forces cannot operate effectively.
POROUS MATERIALS **All unfired clayware, certain fired porous ceramics, certain refractories, semi-vitreous materials, many concretes, unfired cerametal compacts, some fired metallic compacts, carbon and graphite.**	Cannot operate. Tends to work, but again too little of the proper kind of capillarity is present.	Cannot operate. Tends to work on some fired ceramics in this group but background indications tend to obliterate true defects.	Can operate. This test is decisive and reliable with this group of materials.
SLIGHTLY POROUS MATERIALS **A bubble structure is present which may or may not have complete inter-connections. Voids may or may not be present at the surface. Examples are certain fired, partially vitrified unglazed ceramic materials, some cerametals, and some types of carbon and graphite.**	Can operate. Difficulties are experienced with excessive backgrounds but not to the point of preventing inspection. Especially useful for finding the nature and quantity of porosity.	Can operate. Difficulties may be experienced with excessive backgrounds, however.	Can operate. Defects are just barely located. Very poor differential absorption forces are in operation.
NONPOROUS, NONGLOSSY MATERIALS **All (or nearly all) vitrified ceramics which are unglazed. This includes many insulators, radio components, bisque chinaware and the like.**	Can operate. No difficulties encountered.	Can operate. No difficulties encountered.	Cannot operate. No differential absorption at all is present.
NONPOROUS, GLOSSY MATERIALS **This includes any glazed or glossy surfaced ceramic material like porcelain enamel, glass, sanitaryware and dinnerware.**	Can operate until crack narrows to slightly larger than 1.10 micron (0.000004 in.). Otherwise, no difficulties are encountered.	Can operate. Detects cracks well below 1/10 micron (0.000004 in.).	Cannot operate, except where there is a through crack in glazes overlaying porous materials such as semi-vitreous ware.

Which Nondestructive Test for Finding Defects in Ceramic Parts

by **HENRY N. STAATS, Manager, Special Products Div. Magnaflux Corp.**

● YEARS AGO, the nondestructive testing of ceramics was an art. Visual inspection, sometimes with lampblack and oil rubbed on to accentuate defects, was often the only test of an acceptable part. Sometimes each piece was struck to make it ring; an improper ring showed a bad part.

As ceramics began to be used in critical applications—insulators, for example—more reliable nondestructive tests were required. Three new methods have come into general use. Each has special abilities.

Fluorescent Penetrant Method

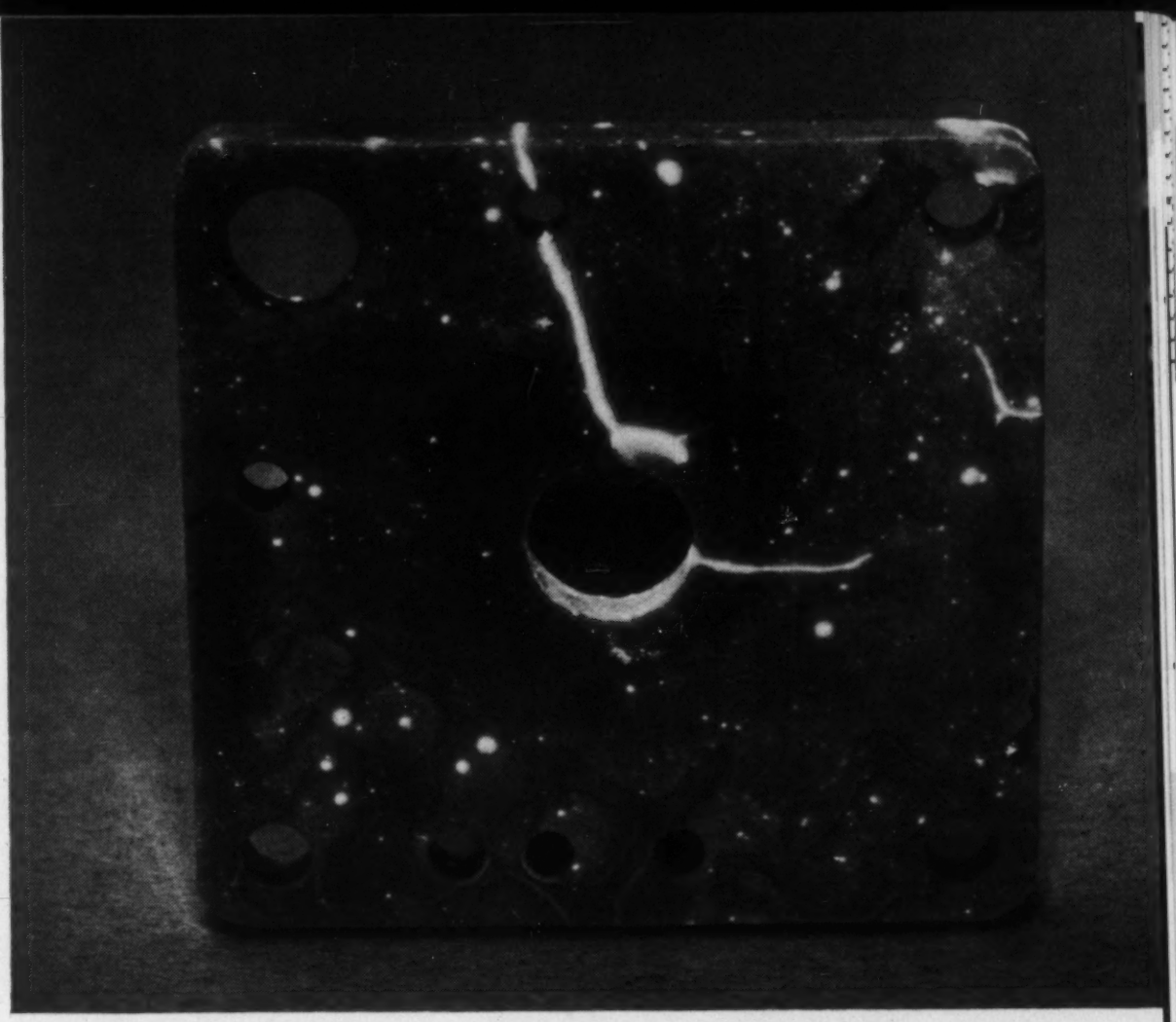
Fluorescent penetrant inspection is used on spark plugs, radio components, radio tubes and insulators. The object is: (1) immersed in a fluorescent penetrating fluid; (2) rinsed (generally in water) to remove the excess penetrant; and finally (3) examined under near ultra violet, or harmless black light. The penetrant enters any crack or surface blemish and is not removed by wiping or rinsing. Capillary action holds it. This penetrant in the crack glows under the near ultra violet light, calling attention to the imperfection. The ceramic surface is sometimes treated with absorbent powder after step 2 to pull the penetrant out of the cracks and increase sensitivity.

The principle of detecting cracks by means of a fluid trapped by capillary action in the cracks is not new. Visual dyes, without near ultra violet inspection, have been used before. The use of an engineered fluorescent fluid and near ultra violet light increases the contrast ratio by perhaps 100 to 1, with a consequent increase in sensitivity.

Electrified Particle Method

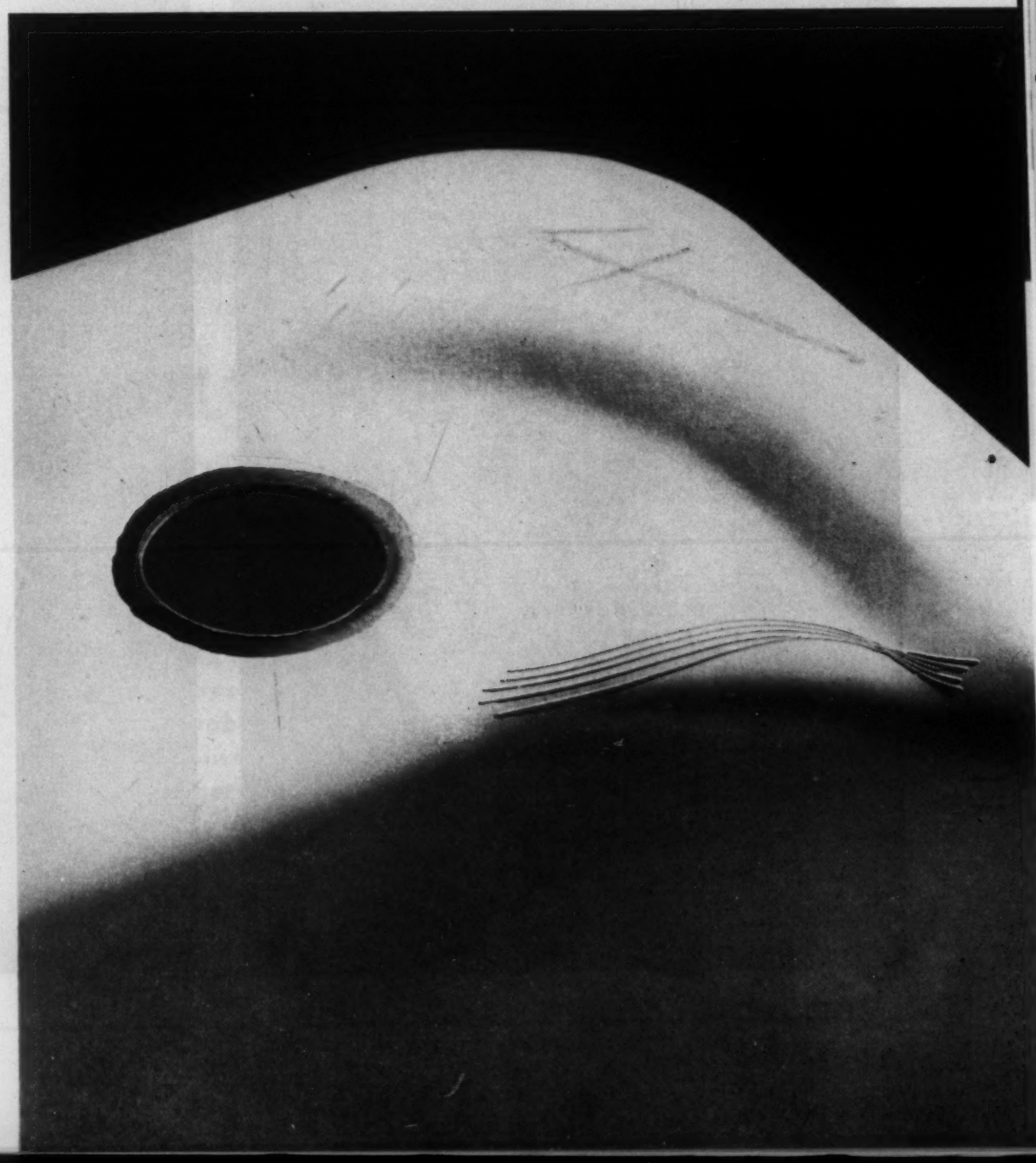
Electrified particle inspection is used to detect flaws in nonconducting materials like glass and porcelain enamel coatings on metals. This method, now nearly 5 years old, relies on electrostatic charges. A powder is blown through a tube and electrons are rubbed off the powder particles, giving them an electrostatic charge. The powder and the tube material are chosen so that the electrons rub off in sufficient quantity to enable the effect to take place. The charged powder is blown over the ceramic surface, where it gathers at cracks, outlining the imperfections.

In ceramic coatings on metals, the powder is attracted to the defect, if



FLUORESCENT PENETRANT *indication of cracks formed in assembling a fired electronic component. The bright spots are a rough indication of porosity.*

ELECTRIFIED PARTICLE *indications of cracks produced in a pressed steel porcelain enameled sink by bending stresses.*



a crack exists, where the electrons tend to leak through. For practical purposes, the crack becomes a line of negative charge, gathering the powder.

In a solid ceramic piece, there is no mobile electron supply from a base metal. The electrons are supplied by introducing a mild electrolyte into the cracks. The electrons in this fluid migrate toward the surface to trap the positively charged powder particles.

This electrified particle method is probably the most sensitive nondestructive test known. At the same time, it is virtually impossible to reduce or control its sensitivity. Cracks can be located that would be impossible to see, even if they were cracks in a transparent material. An interface narrower than one quarter of a wave length of light (0.000004 in.) can be detected. While a fluid can enter defects this small, it is impossible to detect the fluid visually or by blotting, even with fluorescent fluids and near ultra violet light.

Filtered Particle Method

Filtered particle inspection, now about 3 years old, is used on porous surfaces like unfired dried clay, certain fired ceramics, concrete, some powdered metals, carbon and technical ceramics like unsintered tungsten and titanium carbide. A suitable fluid containing properly sized suspended particles is applied to the porous surface. More fluid is absorbed at a defect than anywhere else, due to the extra absorption area within the defect. The suspended particles are wider than the crack and filter out along the crack to form a line indication. Fluorescent particles are now used to give high contrast.

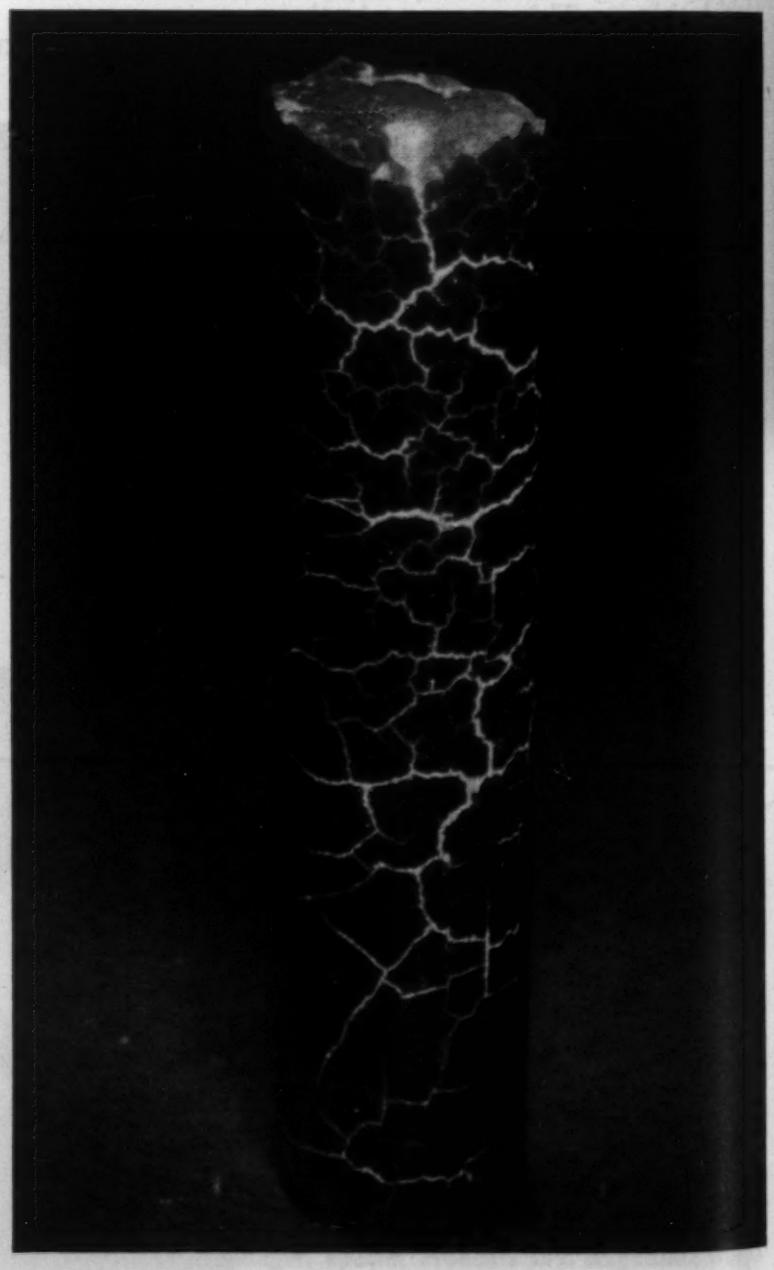
A variation of the technique is to use a soluble dye in the fluid, in addition to the suspended particles. The fluorescent fluid allows the defect to be traced out. The defect can then be removed or pegged and the ceramic product can be salvaged.

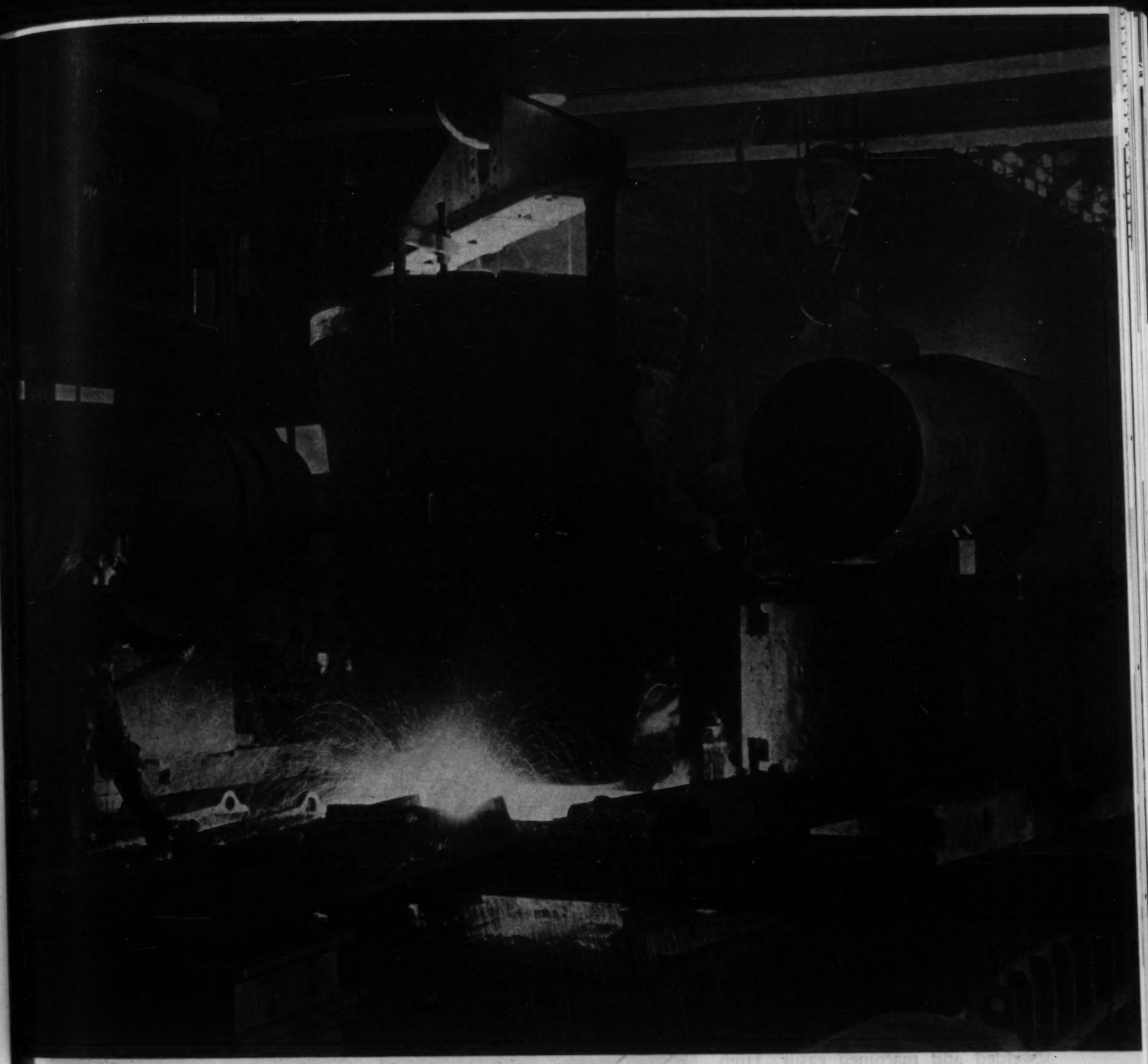
The vast majority of ceramics can be inspected by one of these nondestructive testing methods. For any particular product, a method must first be chosen which can be used on the ceramic material involved. If more than one method can be used, the choice may depend on the sensitivity required. If more than one method fulfills the accuracy requirements, the choice will depend on contamination problems, the ease of inspection, and costs.

This article is adapted from a paper presented at the annual meeting of the Society for Non-Destructive Testing, Oct. 1951.

FILTERED PARTICLE *indication of a crack in a fired, porous combustion tube.*

Fluorescent penetrant inspection shows cracks produced by severe thermal shock in a hard fired unglazed ceramic rod.





Carbon and Low Alloy Steel Castings

by Philip O'Keefe, Associate Editor, Materials & Methods

MATERIALS & METHODS MANUAL No. 86

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

SEPTEMBER 1952

Carbon and low alloy steel castings are used in every important industry. In specifications, design and processing, they are different from comparable rolled, welded or forged steel parts. Close cooperation between the foundrymen and the specifying engineer is needed to get the best steel casting at the lowest price. This Manual gives the materials engineer the information he must have to consult intelligently with the foundry, including:

- *Properties*
- *Design*
- *Heat Treating*
- *Specifications*
- *Joining*
- *Inspection*

Introduction

Carbon and low alloy steel castings are used in every major industry. In weight, they range from a few ounces to over 200 tons. The reliability, strength and versatility of these castings are emphasized by their applications. In the railroad industry, locomotive cylinders and frames, truck frames and wheel centers are cast. Landing gear supports, propeller hubs and engine mounts are aircraft steel castings. Turbine wheel runners, electric motor frames, fighting tank bodies and turrets and machine bases are outstanding large castings. Pipe fittings, truck wheels and dredge cutters are also cast in steel.

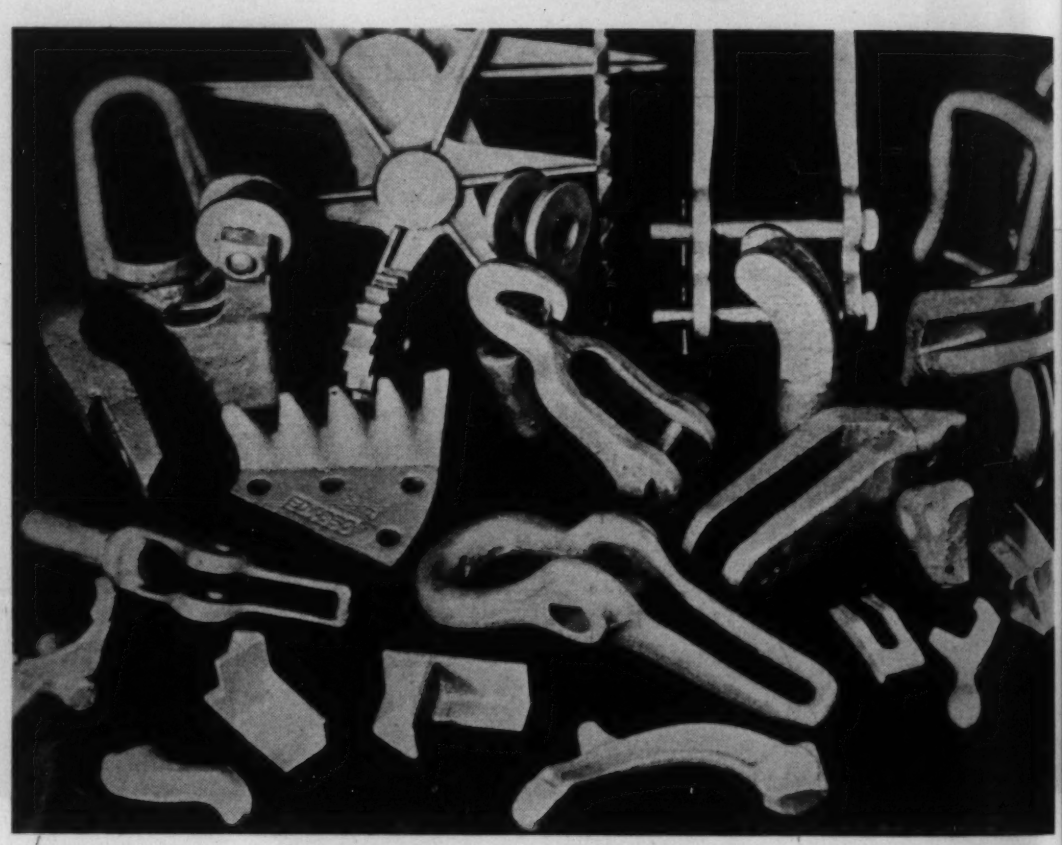
Steel is steel, whether it is cast or wrought. The mechanical properties of cast and wrought forms having the same composition and heat treatment are similar. Cast steels have uniform properties in all directions. Wrought steels show slightly higher ductility in the direction of working. The wrought properties are lower in the transverse direction, however.

Carbon and low alloy cast steels have a number of advantages over other materials. Strength and shock resistance are outstanding. The metal is distributed where it will do the most good. This gives maximum strength for a given weight. A wide range of mechanical properties is available, and the castings can be welded and machined easily. High rigidity, low deflection, accurate alignment, close tolerances and good fits can be secured with steel castings.

Consultation between the foundry and engineer or designer is extremely important. The equipment, the patterns and even the steel analysis used to make a casting will vary from foundry to foundry. Unlike wrought products, no steel casting is a standard item. The foundry experts and the designing engineer must work closely to get the best casting at the lowest price.

This Manual is a guide to the engineer considering steel castings for his product. It is in no way intended to be a substitute for foundry consultation. The discussion is confined to carbon steels and alloy steels with less than 8.0% alloy content. The steels used primarily for outstanding heat or corrosion resistance are not covered.

Cast steel automotive truck wheel spider shows how a casting can be cored to put the metal in the most advantageous places. (Steel Founders' Society of America)



Small parts as well as very large pieces can be made as steel castings. (Calumet Steel Castings Corp.)

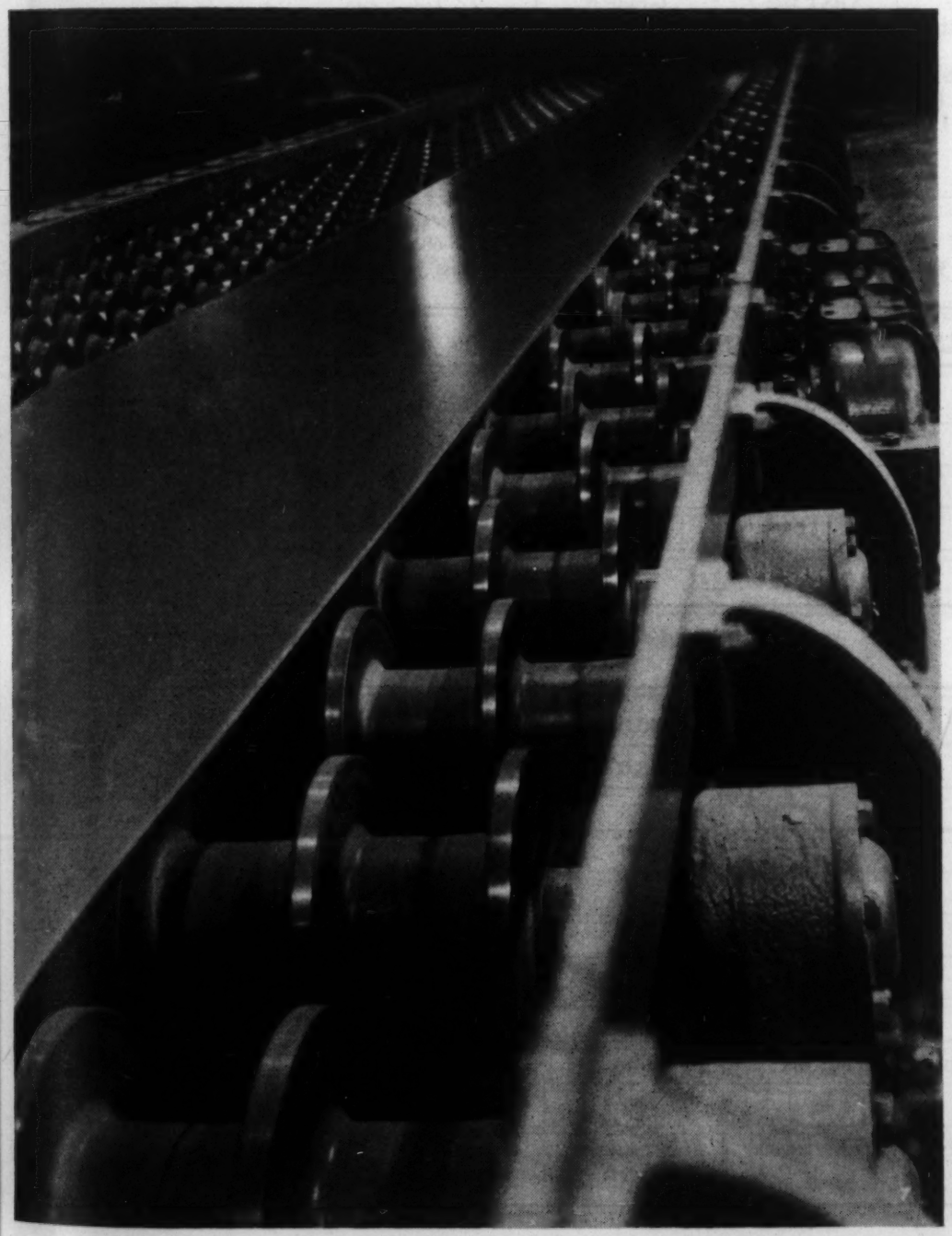
Cast steel four-wheel passenger truck frame for the New York, New Haven and Hartford Railroad. (Steel Founders' Society of America)

Properties and Specifications

Carbon and low alloy cast steels show test properties similar to those of corresponding compositions in wrought steels. The same uncertainties involved in applying published property data in products made from rolled and forged steel are present in specifying steel castings. The properties vary with changes in the composition of the steel. The manufacturing history of a given casting will affect its strength, creep, impact resistance and hardenability. Casting unsoundness may contribute to property variations. Notches and stress concentrations also bring unknown factors into any practical product. The mass effect is another universal factor bearing on the properties of a given steel in a casting. For all these reasons, property values should be considered merely as indications of the results that can be expected from a casting in service, rather than an accurate description of what it will do.

General Properties

Some of the properties of cast steel are reasonably well defined and are not subject to wide variation in practical castings. These properties include modulus of elasticity, modulus of rigidity, density and thermal expansion.



Cast steel run-out table rollers. The journal boxes and motor housings are also steel castings. (Steel Founders' Society of America)

The modulus of elasticity is the ratio of stress to strain within the elastic limit. The value used for steel is 30 x 10^6 psi. The exact value seems to decrease slightly as the carbon content is raised. For practical purposes, however, this change is negligible. The modulus of elasticity does decrease significantly with temperature increases, though. At 900 F it drops to about 22 x 10^6 psi. This must be considered in using steel castings at elevated temperatures.

The torsional modulus of rigidity can also be considered constant at room temperature for engineering purposes. The value usually accepted is 11.2 x 10^{-6} psi. Poisson's Ratio, the ratio of lateral contraction to longitudinal extension under stress, is considered to be 0.3 for engineering purposes.

The density of cast steel varies with the composition, structure, soundness and temperature of the metal, and with its phase changes. The density decreases as the temperature and the carbon content increase. The effect of other alloying elements varies and is usually not significant.

The electrical resistivity of steel increases with the carbon content. Other alloying elements also increase with the temperature of the metal, of course. Heat treatments have significant effects. Annealed steel has the lowest resistance. Quenched and tempered carbon steel shows decreasing resistivity as tempering temperature is raised. With annealed carbon steel, the resistivity is given as: 13 to 14 microhm cm for 0.07 to 0.20% carbon; 14 to 16 microhm cm for 0.20 to 0.45% carbon; 16 to 20 microhm cm for 0.45 to 1.50% carbon.

The carbon and alloy contents of a cast steel are important in determining its magnetic properties. Carbon, manganese, phosphorus, sulfur and silicon increase the hysteresis loss. The magnetic properties of annealed dynamo cast steel are given as: maximum permeability, 14,800; hysteresis loss (inductor for H 150), 19,100; saturation magnetization 21,420 gausses; residual induction 11,000 gausses; coercive force, 0.37 oersteds. A chemical specification for dynamo cast steel and low carbon cast steel for electrical purposes is: 0.05 to 0.15 carbon, 0.20 max. manganese and 0.35 to 0.60% silicon.

The thermal conductivity of plain

General Engineering
(Classified According to

STRUCTURAL GRADES—CARBON STEELS						
Tensile Strength, Psi	60,000	65,000	70,000	80,000	85,000	100,000
Indicated Application	Low electric resistivity. Desirable magnetic properties, carburizing and case hardening grades. Weldability.	Excellent weldability. Medium strength with good machinability and high ductility.		High strength carbon steels with good machinability, toughness and excellent fatigue resistance.		Wear resistance hardness.
Current Specifications	ASTM: A27-46T U60 — 30 60 — 30 ASTM: A216-44T WCA AAR: M201-46 Grade AU Grade AA Federal: QQ-S-681b Class 1 Navy: 49S1 Class B & D ABS Class 1	ASTM: A27-46T 65 — 30 65 — 35 SAE: Automotive 0030 Federal: QQ-S-681b Class 2 ABS Class 2 Lloyds Class A	ASTM: A27-46T 70 — 36 ASTM: A95-44 70 — 36 ASTM: A216-44T WCB AAR: M201-46 Grade B AREA	SAE: Automotive 080 Federal: QQ-S-681b Class 3 Navy: 49S1 Class A	SAE: Automotive 0050	SAE: Automotive 0050
A Typical Specification for the Tensile Grade with Requirements Listed Below	ASTM A27-46T Class 60 - 30	ASTM A27-46T Class 65 - 35	AAR M201-46 Grade B	Federal QQ-S-681b Class 3	SAE: Automotive Class 0050	SAE: Automotive Class 0050
All values listed below are specification minimum values.						
Tensile Strength, Psi	60,000	65,000	70,000	80,000	85,000	100,000
Yield Point, Psi	30,000	35,000	38,000	40,000	45,000	70,000
Elongation in 2 In., %	24	24	24	17	16	10
Reduction of Area, %	35	35	36	25	24	15
Brinell Hardness No.	—	—	—	—	170	207
Values listed directly below are those normally expected in the production of steel The values listed below are only for general information and						
Tensile Strength, Psi	60,000	65,000	70,000	80,000	85,000	100,000
Yield Point, Psi	30,000	35,000	38,000	45,000	50,000	70,000
Elongation in 2 In., %	30	30	28	26	24	20
Reduction of Area, %	50	53	50	43	40	43
Brinell Hardness No.	120	130	140	160	175	215
Charpy Impact at 70 F ft-lb**	35	35	30	35	30	25
Charpy Impact at —50 F ft-lb**	8	12	10	12	12	15
Endurance Limit, Psi	25,000	28,000	31,000	35,000	38,000	47,000
Modulus of Elasticity	30 million psi	30 million psi	30 million psi	30 million psi	30 million psi	30 million psi
Machinability Rating†	55	60	65	70	70	65
Type of Heat Treatment	Annealed	Normalized	Normalized	Normalized and tempered	Normalized and tempered	Quenched and tempered

* *Below 8% total alloy content.*
** *Keyhole notch.*
† *Machinability rating by Research Committee on Cutting Fluids—"Metal Progress," Oct. 1943, pp. 622–624. Cold rolled screw stock equals 100.*
†† *Test values obtained in accordance with ASTM testing procedures.*
‡ *SAE hardness requirement.*

Types of Steel Castings

Tensile Strengths)

		ENGINEERING GRADES—LOW ALLOY STEELS*						
70,000	80,000	90,000	100,000	110,000	120,000	150,000	175,000	200,000
Excellent weldability. Medium strength with high toughness and good machinability.		Certain steels of these classes have excellent high temp properties and deep hardening properties. Toughness.		High resistance to impact. Excellent low temp properties for certain steels. Deep hardening. Excellent combination of strength and toughness.		Deep hardening. High strength. Wear resistance. Fatigue resistance.	High strength. Wear resistance. High hardness. High fatigue resistance.	
ASTM: A157-44 C 1 ASTM: A217-46T WC 1 WC 2 WC 3 Navy: 46S33 (Int) A	ASTM: A148-46T 80 — 40 80 — 50 ASTM: A217-46T WC 4 SAE: Automotive 080 Federal: QQ-S-681b 4A1	ASTM: A148-46T 90 — 60 ASTM: A157-44 C 3 SAE: Automotive 090 Federal: QQ-S-681b 4A2, 4B1, 4B2, 4C1 Navy: 49S1 (Int) Grade F AAR: M201-46 Grade C	ASTM: A157-44 C 11 Federal: QQ-S-681b 4B3	ASTM: A148-46T 105 — 85 SAE: Automotive 0105 Federal: QQ-S-681b 4C2	ASTM: A148-46T 120 — 100 SAE: Automotive 0120 Federal: QQ-S-681b 4C3	ASTM: A148-46T 150 — 125 SAE: Automotive 0150 Federal: QQ-S-681b 4C4	ASTM: A148-46T 175 — 145 SAE: Automotive 0175	None specified
ASTM A157-44 Class C1	ASTM A148-46T Class 80 - 50	ASTM A148-46T Class 90 - 60	Federal QQ-S-681b Class 4B3	ASTM A148-46T Class 105 - 85	ASTM A148-46T Class 120 - 100	ASTM A148-46T Class 150 - 125	ASTM A148-46T Class 175 - 145	None specified

All values listed below are specification minimum values.

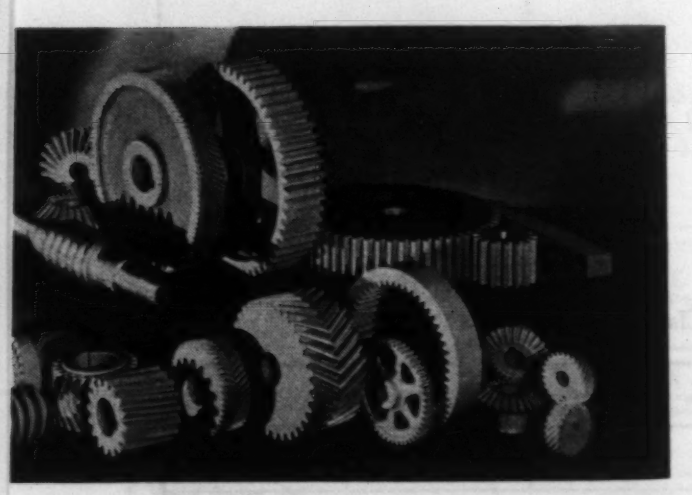
70,000	80,000	90,000	100,000	105,000	120,000	150,000	175,000	—
45,000	50,000	60,000	65,000	85,000	100,000	125,000	145,000	—
22	22	20	17	17	14	9	6	—
35	35	40	30	35	30	22	12	—
—	—	—	—	217‡	248‡	311‡	363‡	—

castings for the tensile strength values given in the upper portion of the chart.†† are not to be used as design or specification limit values.

70,000	80,000	90,000	100,000	110,000	120,000	150,000	175,000	200,000
42,000	50,000	60,000	65,000	85,000	97,000	130,000	148,000	175,000
28	27	24	21	18	16	12	8	5
55	50	50	46	42	38	25	15	11
140	160	190	215	235	260	325	380	420
35	30	26	22	28	24	18	10	—
15	15	17	15	22	18	15	6	—
33,000	38,000	41,000	45,000	49,000	55,000	65,000	77,000	85,000
30 million psi	30 million psi	30 million psi	30 million psi	30 million psi	30 million psi	30 million psi	30 million psi	30 million psi
65	70	70	65	60	50	30	—	—
Normalized and tempered	Normalized and tempered	Normalized and tempered	Normalized and tempered	Quenched and tempered	Quenched and tempered	Quenched and tempered	Quenched and tempered	Quenched and tempered

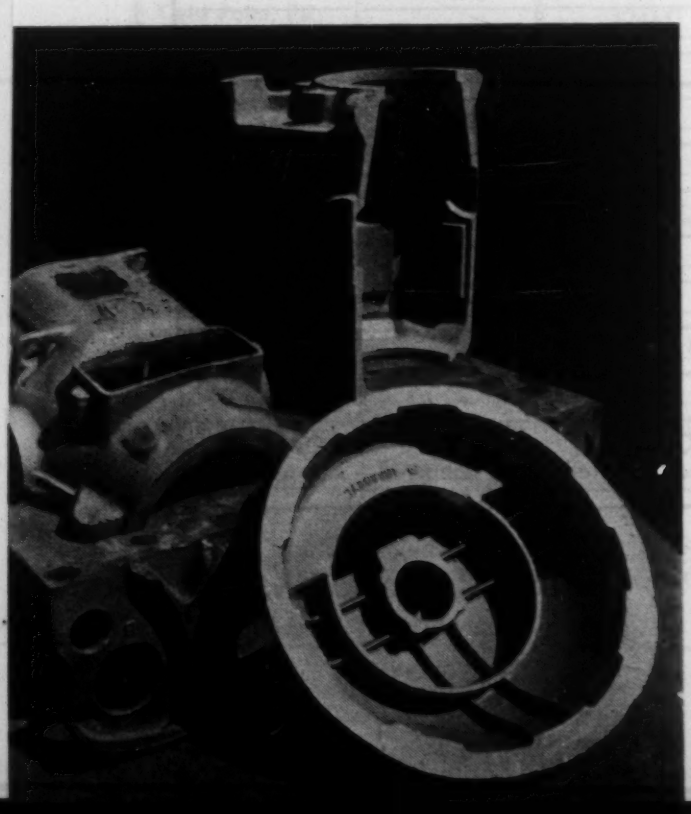
Steel Founders' Society of America

Integral cast steel runner for a small hydraulic turbine. (Steel Founders' Society of America)



Gears of all types and sizes are made of cast steel. Some gears are cast directly, with no machining required. In any case, machining costs are lowered. (Steel Founders' Society of America)

Steel castings are important in electrical machinery. Motor frames and end brackets are typical examples. (Westinghouse Electric Corp.)



carbon steel varies from 2904 to 3388 Btu per sq ft per ft per hr per F. It increases as the temperature and the carbon content go down.

Mechanical Properties

The mechanical properties of cast steel are the most important data used by the engineer in specifying a casting. Tensile strength, hardness, impact strength, ductility and yield point are considered in shaping a practical casting.

These properties are all covered by published tables and charts. They are often checked on test pieces attached to the casting or cast separately. The values obtained from either of these sources are only indicative of the properties of the steel, however. They cannot be relied upon completely to accurately portray the properties of the material in a commercial casting. The same problem of interpreting test results is met to some extent in other forms of steel—forgings, weldments and rolled shapes.

In using any table values of mechanical properties for steels, the engineer should realize that these values are only the normally expected values. There are fairly wide variations between manufactured lots of any given steel grade. The carbon and alloy content will vary between limits. The manufacturing processes themselves cannot be controlled exactly either. Other variations are bound to occur in the heat treatments given castings. Tested under ideal conditions, different lots of steel will show significant differences in mechanical properties even though they are produced to the same content specifications. Tensile strength and yield point will often vary over a 20% range in a large number of production heats of a given grade of carbon steel.

Test specimens cast with the commercial casting are a more accurate method of checking the values of the material than merely using handbook figures. The engineer must recognize, however, that inaccurate conclusions can be drawn from these tests, too. The quality and properties of the test specimen will depend on the size of the specimen and how it was cast. The metal in the casting itself will vary between locations in the sections. The internal metal may not show as high mechanical properties as the surface material. In destructive testing, a well designed casting may even show better properties than those indicated by an integrally or separately cast test specimen. The values shown on specimens cut out of a casting itself may vary from figures taken from production test specimens by 20%, or even more.

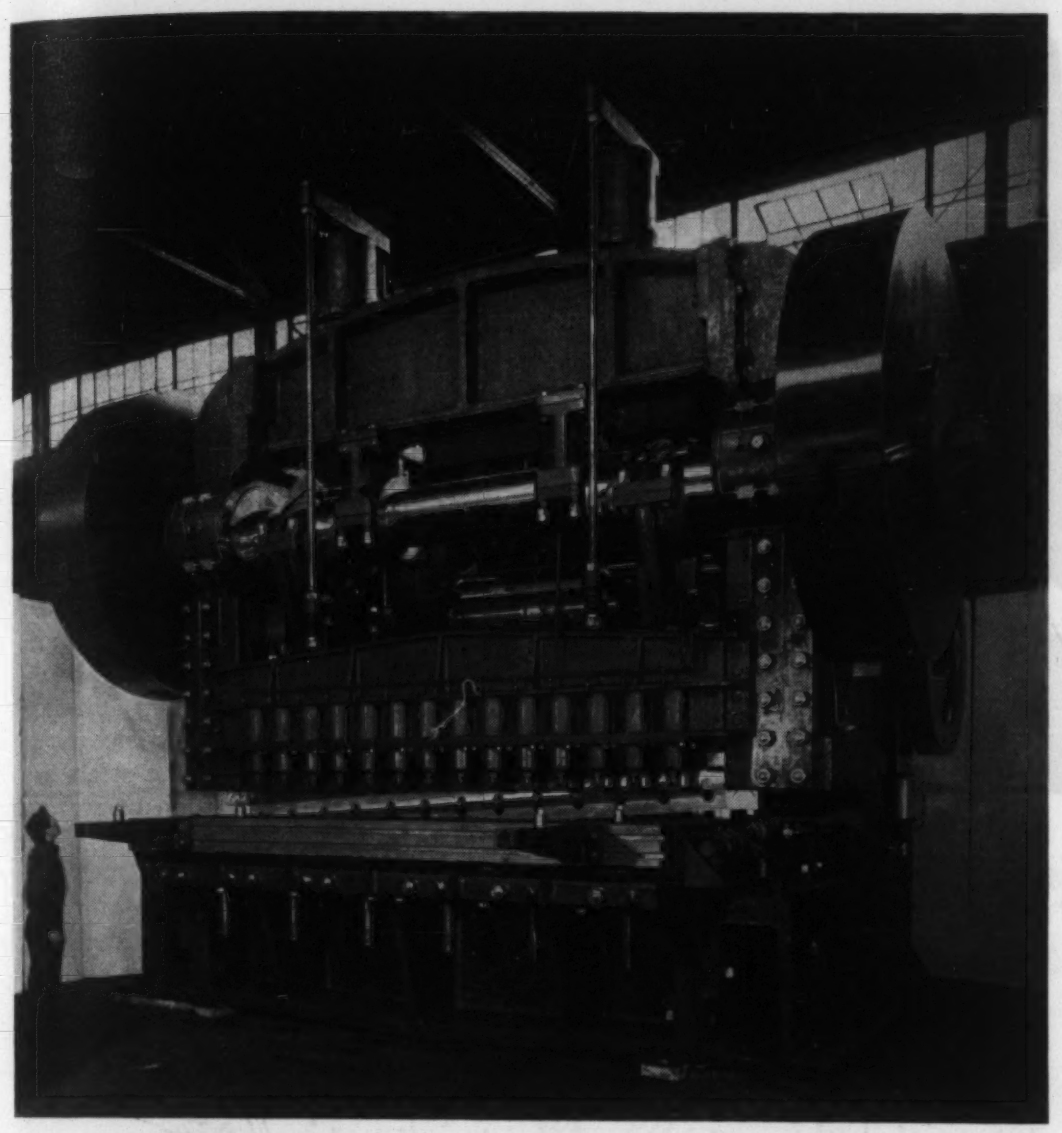
Even if a casting were entirely homogeneous in its mechanical properties, and if these properties were known accurately, the stress concentrations found in practice would create another factor of uncertainty. In a mass produced casting, these unknowns can be minimized by careful stress analysis. In many castings, however, very little study can be afforded.

Carbon Steel Castings

Carbon steel castings are often considered as containing less than 1.70% carbon, along with other elements normally present in steel castings. These elements vary, but the usual ranges are: 0.50 to 1.00 manganese, 0.25 to 0.85 silicon, 0.05 max phosphorus, and 0.06% max sulfur. Steel with a carbon content below 0.20% is classified as low carbon steel. Manganese, silicon, phosphorus and sulfur are also present. Low carbon steels are used in railroad, automotive and electrical machinery castings.

The mechanical properties shown by test bars of low carbon steels are about the same in the as-cast and annealed states. Castings in which stress concentration is significant are annealed to relieve internal stresses. The increase in mechanical properties derived from quenching and tempering is small, although impact resistance can be increased by this heat treatment.

In the annealed state, hardness, tensile strength and yield point increase with carbon content. Reduction of area and elongation decrease. Test values for carbon contents of 0.08 to 0.20% range from: 115 to 130 Brinell hardness; 55,000 to 68,000 psi tensile strength; 28,000 to 37,000 psi yield point; 66 to 53% reduction of area; and 37 to 32% elongation. The endurance limit is usually taken as 40% of the tensile strength. Annealed steels in this range reach a maximum in tensile strength at 400 to 600 F. Above this maximum, tensile strength decreases. The yield point decreases steadily as temperature goes up. In low temperature impact strength



The rigidity, strength and intricateness of large steel castings make them a preferred material form for large machinery bases. (Steel Founders' Society of America)

tests, the lower carbon steels give better results.

Carbon contents of 0.20 to 0.50% characterize the plain medium carbon cast steels. About 60% of the steel castings made fall into this class. Manganese, silicon, phosphorus and sulfur are the other elements normally found. Medium carbon steel castings are used in railroad, machine tool, rolling mill, construction and other applications.

These castings are usually heat treated to relieve casting stresses and refine the grain structure. A wide range of mechanical properties can be obtained by varying the heat treating temperatures. Large castings are usually annealed. Small and medium size castings are usually normalized. Some of these medium carbon castings are quenched and tempered.

Steels in the medium carbon range in the annealed condition show properties ranging from: 68,000 to 96,000 psi tensile strength; 36,000 to 53,000 psi yield strength; 52 to 25% reduction of area; and 31 to 18% elongation. Impact strength at room temperature is improved by normalizing and by quenching and tempering. The impact strength of these grades falls off rapidly at lower temperatures, however. The ASME gives the allowable working stresses for medium carbon cast steels as varying from 1350 to 2000 psi at 1000 F. Higher stresses can be taken at lower temperatures. It is thought that cast steels in this range have a somewhat greater resistance to creep at elevated temperatures than rolled or forged steels. This is probably due to their uniformly large grain size in all directions.

Castings with more than 0.50% carbon are classified as high carbon steel. Manganese, silicon, phosphorus and sulfur are also present in plain high carbon steel. These compositions are used in dies, rolls, machine tool parts and other castings which require high hardness, high rigidity and resistance to abrasion.

These steels are always annealed, as a preliminary heat treatment. A normalizing and tempering treatment is also used as a secondary treatment in some applications, and some castings are even oil quenched and tempered.

In the full annealed state, high carbon mechanical properties vary from: 95,000 to 128,000 psi tensile strength; 52,000 to 63,000 psi yield strength, 180 to 250 Brinell hardness; and 25 to 5% reduction of area.

Low Alloy Steel Castings

For applications which require higher or lower operating temperatures, higher strength, greater wear resistance and higher impact resistance than are available in carbon steels, the low alloy steels have been developed. Perhaps one hundred alloy grades have been used commercially, but the tendency is to reduce the number used. A comparatively small number of alloys, with proper heat treatment, can give the properties desired in most castings.

Practically all alloy castings are heat treated. Highest strengths are imparted in the quenched and tempered state. There are no general rules as to the mechanical properties attained, however, since a wide range can be covered with various alloy contents and heat treatments. Tensile strengths over 160,000 psi and yield points over 145,000 psi can be obtained. Various alloys are specifically intended for high temperature service, high impact strength at low temperature, wear resistance and other severe service applications.

An important characteristic of alloy steels is their ability to air harden. Complicated castings can be hardened with these alloys, and tensile strengths from 70,000 to 100,000 psi obtained without quenching. Manganese is widely used as an alloying element. It is a cheap and efficient hardening agent. Vanadium, titanium and aluminum are often used with manganese to refine the grain structure. Nickel and molybdenum with manganese are not as effective as grain refiners, but increase the capacity to air harden.

Several elements impart hardness and wear resistance. Chromium and nickel are used together in wear resistant castings. Chromium is also used with molybdenum, vanadium and manganese for the same purpose. Nickel-vanadium, manganese-molybdenum and nickel-manganese cast steels are used for wear resistance and high strength.

Copper-bearing steels are valuable for their high ratio of tensile to yield strengths. High fluidity is also char-

The fluid end of an oil field mud pump is a one-piece steel casting. (Texas Electric Steel Casting Co.)

acteristic of copper steels, and they are used extensively for castings with long thin sections.

Some low alloy steels are also used for high and low temperature applications. Cast steels containing chromium, molybdenum, vanadium and tungsten give good service under steam exposure up to 1200 F. Nickel and nickel-vanadium steels are specified for low temperatures.

Specifications

Steel castings are usually ordered to standard specifications. The mechanical properties are specified and the composition, within limits, is left up to the supplier. The ASTM, the SAE, the government agencies and the railroads all have recognized standards. While buyers occasionally ask for given chemical composition steels, this practice is not recommended for carbon and low alloy steels. Restrictions on chemical composition may make it difficult for the foundry to meet the property requirements. These restrictions, even when they are possible to meet, will often add to the cost of a casting. Chemical composition can become more important than mechanical properties, however, where steels are used mainly for corrosion or scaling resistance.

A summary of standard specifications for steel castings appeared in MATERIALS & METHODS, "Materials Engineering File Facts" section, pp. 121 & 123, July, 1952. This chart gives the minimum mechanical properties and the maximum chemical composition percentages for each class of each specification.

Design of Steel Castings

Experience has laid down a number of special rules that should be followed, if possible, in designing a steel casting. A structure departing from one or more of these principles can often be cast successfully. Nevertheless, the casting which conforms to the rules will be more serviceable and cheaper than one which requires special foundry techniques.

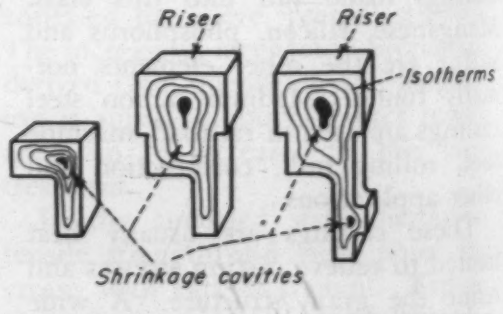
Possible Defects

Several natural characteristics of steel must be considered in laying out a casting. In comparison to other metals, liquid steel does not flow easily through intricate passages. Higher pouring temperatures help this trouble but create other problems. Steel also shrinks more than many metals in solidifying and cooling. With no constraint, 0.30% carbon steel contracts 0.89% per 100 F in the liquid state, 3.0% at solidification and 7.2% cooling to room temperature in the solid state. These natural characteristics predispose badly designed castings to certain defects. These defects are the fault of the design, not the material. The most harmful defects are:

Sand Inclusions—If a casting is too complicated, the sand mold will be difficult to make. When the liquid steel is poured, parts of the mold walls or core may be washed away. This sand may be trapped in the casting.

Misruns—Complicated pieces with thin sections may not be completely filled with molten metals. Liquid steel will often fail to fill wide, thin webs, for example. The remedy is narrower, thicker webs.

Shrinkage Cavities—If molten steel feeds through a thin section to a thick section, a shrinkage cavity is likely to form in the thick section.

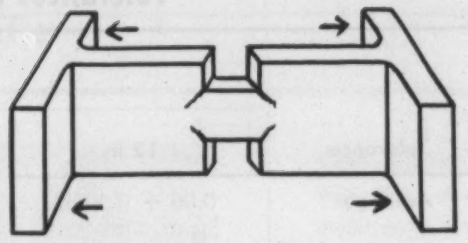


Shrinkage cavities can be avoided by using uniform sections or by having thick sections feed thin sections. Correctly placed risers are another solution. (Steel Founders' Society of America)

The thin section solidifies before the thick section, cutting off the supply of molten steel to the thick section. As the middle of the thick section solidifies, it contracts, leaving a cavity. No molten steel can feed in through the already solidified thin section to fill this cavity. The best

precaution is to make all sections the same thickness. If this cannot be done, the foundry can often find other ways to prevent these defects. Thick sections may feed thin sections, or risers can be used to fill isolated heavy sections.

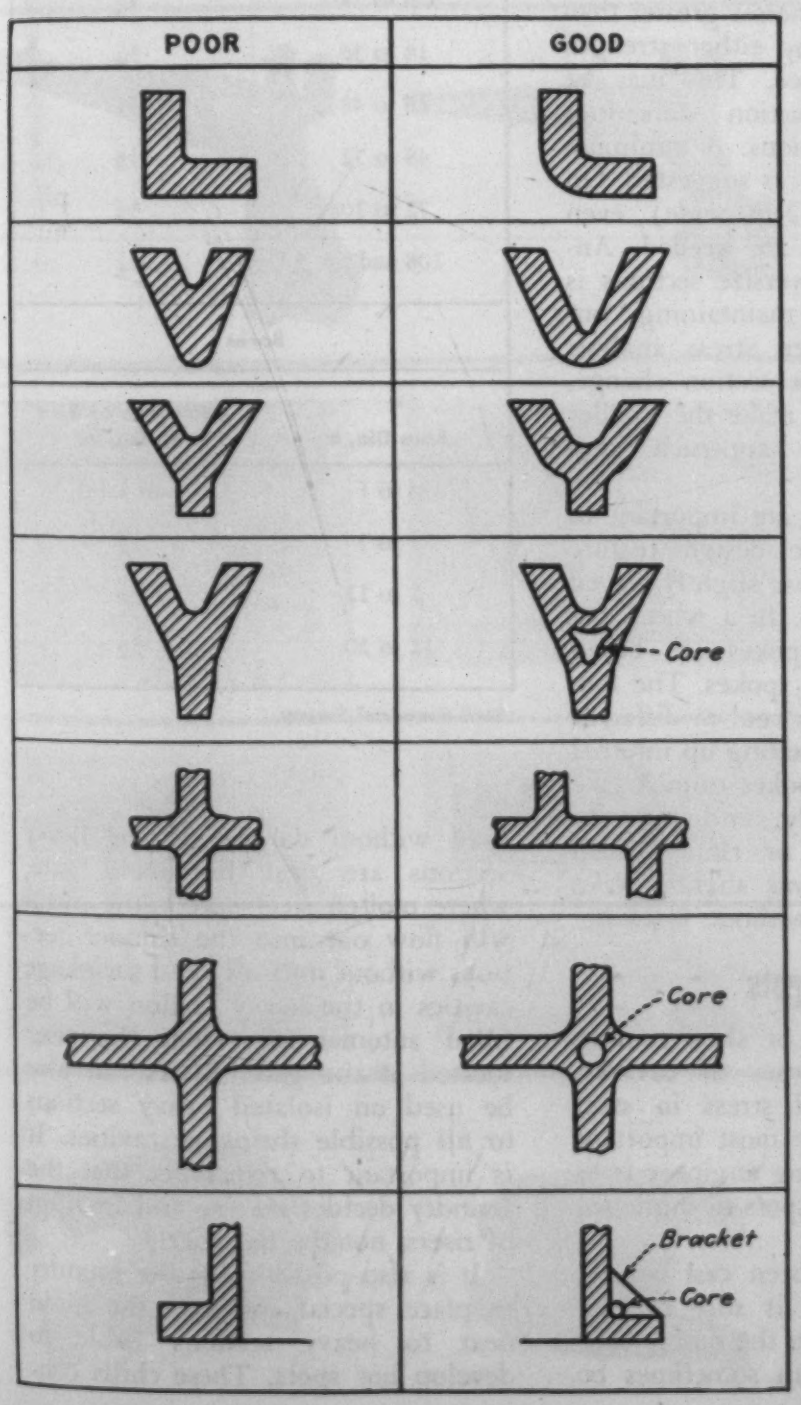
Hot Tears—The high shrinkage and low hot strength cause hot tears. Since thin sections solidify quicker than thick sections, stresses are set up in a casting during cooling. These stresses are likely to crack the casting at the points that are slow to cool (hot spots), particularly when stress risers like notches and abrupt section changes are near the hot spots. The engineer can avoid hot tears by minimizing hot spots and stress risers.

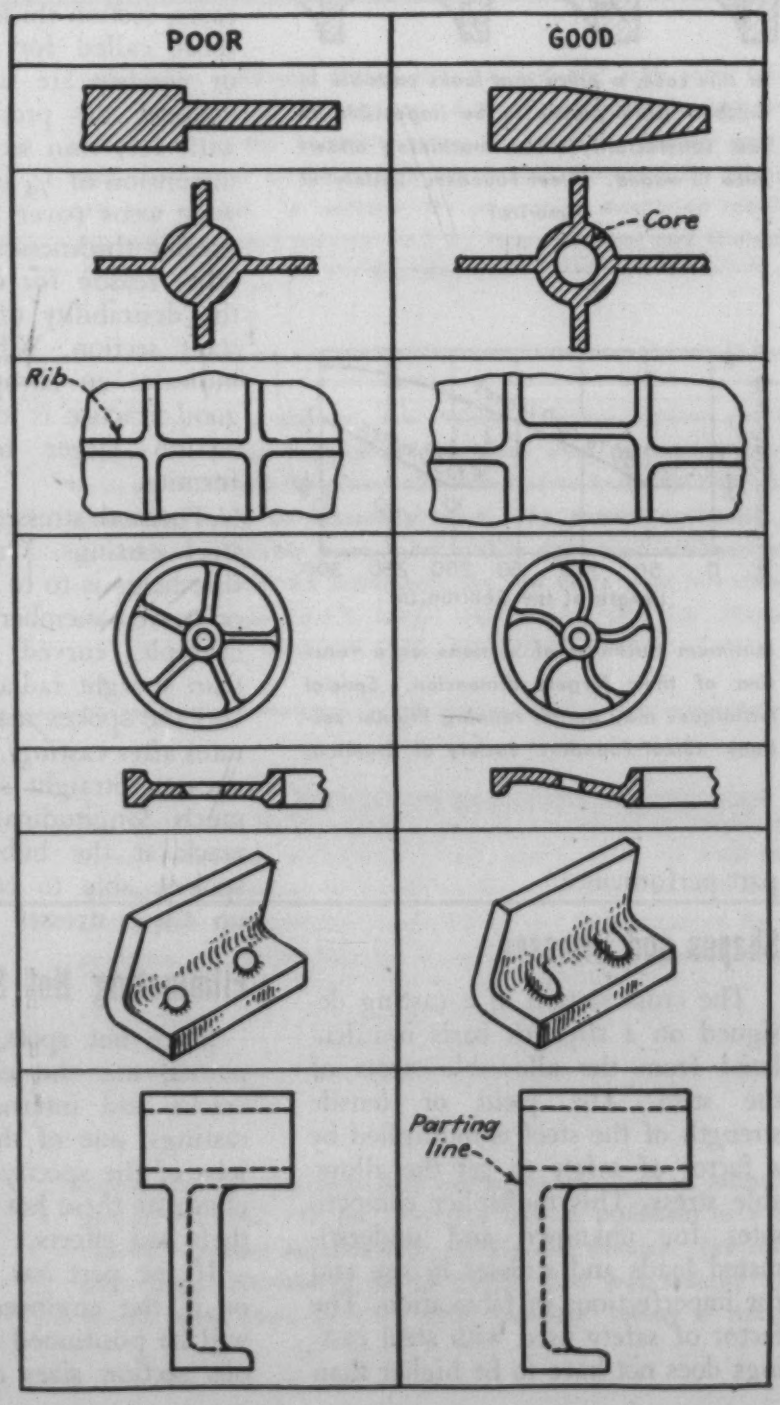


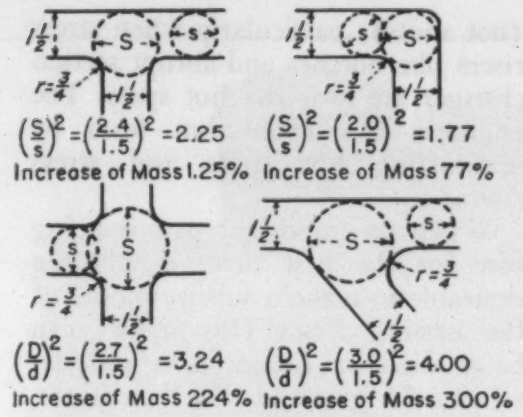
Hot tears result from stresses put on the casting while the steel is hot and weak. Contraction that is opposed by the sand mold is one cause. Abrupt section changes and other stress risers are danger points.
(Steel Founders' Society of America)

When an important part is being cast for the first time, it is often desirable to make a subsize model of the casting first. This model can be studied by foundrymen and designers. In give-and-take discussions, possible production defects can be guarded against without affecting

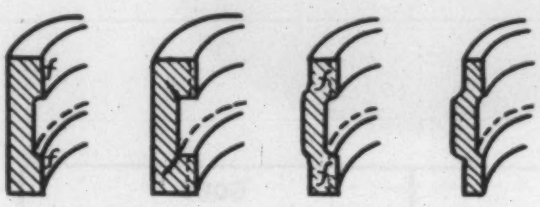
Casting Design Details



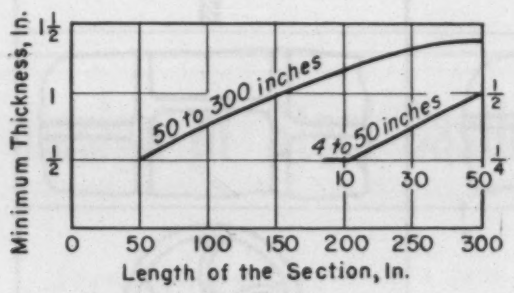




Inscribed circles are used to determine effect of section changes and joints in forming hot spots in castings. The smaller the mass increase, the less likely defects will occur. (Steel Founders' Society of America)



In this case, a piece that looks castable in finished state proves to be impossible to cast satisfactorily when machining allowance is added. (Steel Founders' Society of America)



Minimum thickness of sections as a function of their largest dimension. Special techniques may permit running thinner sections. (Steel Founders' Society of America)

part performance.

Shapes and Stresses

The cross section of a casting designed on a strength basis is calculated from the allowable stress of the steel. The yield or tensile strength of the steel is multiplied by a factor of safety to get the allowable stress. This multiplier compensates for unknown and understimated loads and stresses in use and for imperfections in fabrication. The factor of safety used with steel castings does not have to be higher than that used with other steel forms. According to steel founders, steel castings are no more subject to manufacturing difficulties than a forging or a weldment.

The thickness of a section is not always specified solely on stress or strain analysis, however. In some cases, section thicknesses greater than those called for by either strength or rigidity are used. This may be because of production difficulties with very thin sections. A minimum dimension of ¼ in. is suggested. On wide webs (over 12 in. wide), even greater thicknesses are needed. Another reason for oversize sections is the desirability of maintaining constant section. When stress analysis indicates an abrupt section change, good practice is to make the smaller section larger to approach uniformity.

Thermal stresses are important in steel castings. One design feature that helps is to to use slightly waved or curved members. In a wheel, for example, curved spokes are better than straight radial spokes. The hub and the spokes may cool at different rates after casting, setting up internal stresses. Straight spokes cannot give much longitudinally, and tend to crack at the hub or rim. Curved spokes, able to bend slightly, take up these stresses without cracking.

Eliminating Hot Spots

Since hot spots, or slow cooling points, are the causes of cavities, cracks and internal stress in steel castings, one of the most important jobs of the specifying engineer is to eliminate these hot spots or minimize their bad effects.

If the part has been cast before, or if the engineer is sure how it will be positioned in the mold, various section sizes can sometimes be used without danger. If the heavy sections are near the mold gate, where molten steel enters, the metal will flow out into the thinner sections without difficulty and shrinkage cavities in the heavy section will be filled automatically from the riser located at the gate. Risers can also be used on isolated heavy sections to fill possible shrinkage cavities. It is important to remember that the foundry decides on use and location of risers, not the designer.

It is also possible for the foundry to place special chills in the mold next to heavy sections liable to develop hot spots. These chills con-

Tolerances for Steel Castings

Tolerance	Dimension		
	12 In.	12–36 In.	36–120 In.
Average	0.06 + 0.006D 1/16 in. min	0.06 + 0.006D	0.08 + 0.006D
Concise	0.04 + 0.005D 1/16 in. min	0.05 + 0.005D	0.07 + 0.005D
Minimum	0.03 + 0.C04D 1/16 in. min	0.04 + 0.004D	0.06 + 0.004D

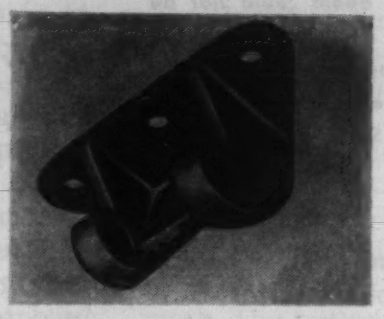
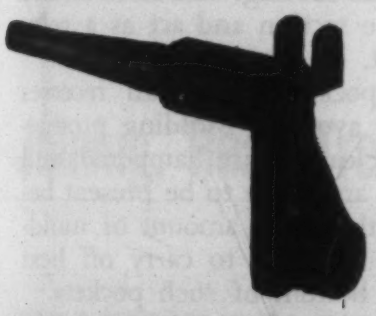
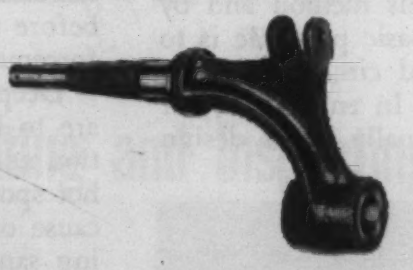
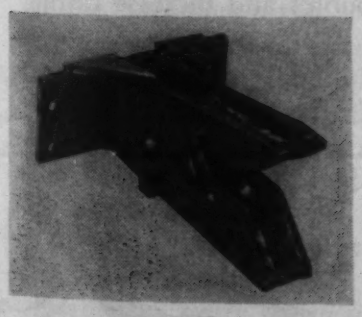
D = Longest dimension of casting (in.). *Steel Founders' Society*

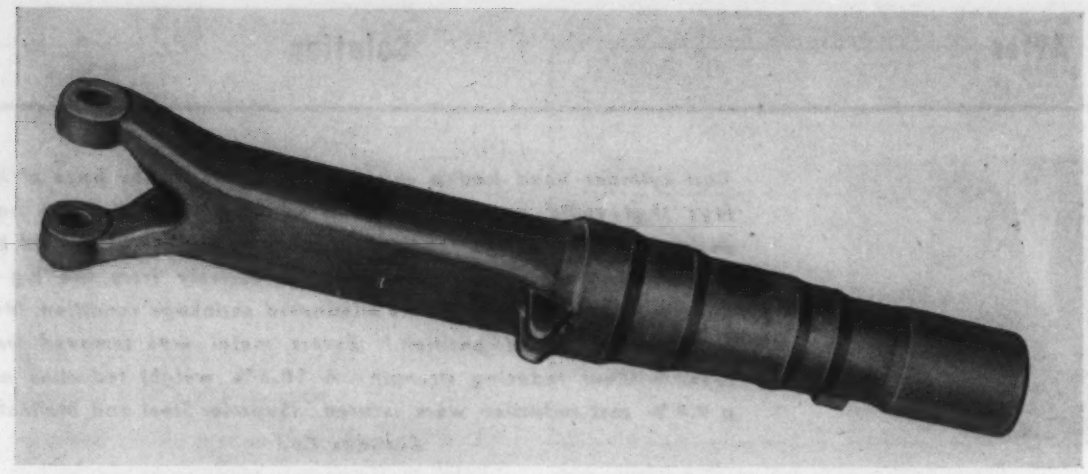
Guide to Machining Allowances

Rings, Spoked Wheels, Spoked Gears, Circular Shaped Castings	
Casting Dia, In.	Allowance on Outside Radius, In.
Up to 18	¼
18 to 36	5/16
36 to 48	⅜
48 to 72	½
72 to 108	⅝
108 and up	¾
Bores	
Bore Dia, In.	Allowance on Bore Radius, In.
Up to 1	Cast solid
1 to 7	¼
7 to 12	⅜
12 to 20	½

Steel Founders' Society.

Some Casting Redesigns

Before	After	Solution
		Cast cylinder head had a shrinkage condition at the base of the lugs that could not be controlled consistently. Expensive non-destructive testing was required. Increasing the metal toward the rim allowed the steel to solidify progressively from the lug to the rim to feeding risers. This eliminated shrinkage condition. (Part is cast in inverted position.) Excess metal was removed from lugs, without reducing strength. A 10.6% weight reduction and a 9.4% cost reduction were secured. (Superior Steel and Malleable Castings Co.)
		Too expensive originally, this hinge butt required too much coring. It was a problem to keep cored hinge holes parallel to the base. The new design eliminated two cores by putting the bosses on the inside. The cores for the hinge pin and the main base were made integral, assuring alignment between the holes and the base. Ribs were placed better to carry the loads. Cost was cut 15.9%, weight from 12.2 to 9.8 lb. (Superior Steel and Malleable Castings Co.)
		Trailer axle weldment lacked strength and met with sales resistance due to poor appearance. A steel casting was considered practical since the quantities were too small to pay for forging dies. The metal distribution in the casting increased the strength and eye appeal. In addition, the amount of machining required was cut. Cost was reduced 28.2%. (Superior Steel and Malleable Castings Co.)
		As a 13-piece weldment, the rockers and stop brackets for this hopper were too expensive. One-piece steel castings were the answer. All machining was eliminated since holes for track pegs and bolts could be accurately cored. The pattern equipment required was relatively inexpensive. While right- and left-hand parts were needed with the weldments, the cast parts were interchangeable. Costs were 23.4% lower; weight was cut 8.5%. (Superior Steel and Malleable Castings Co.)
		This warehouse trailer coupling housing is subjected to considerable stress. Production was slow as a weldment, 40 in. of weld being required. Conversion to a steel casting not only increased the life of the part and speeded up production, but also improved the appearance. The cost reduction amounted to 25%. (Unitcast Corp.)
		Before redesign this idler gear rocker arm for a steam locomotive booster weighed 147 lb. Changing from a weldment to a steel casting increased dependability, rigidity and strength. The casting gave better distribution of the metal. Cost was reduced 12%. Weight went down by 5%. (Steel Founders' Society of America)



In the original design, the wall thickness on this 1240-lb cast steel boom could not be held. The long center core could not be held in position. Placement and removal of the core was difficult. Gas pockets could not be eliminated from the casting because gas from the core could not be vented in pouring. By casting two holes in each side, all these problems were solved. Plates were welded in afterwards. (Superior Steel and Malleable Castings Co.)

duct heat away faster than sand next to thin sections, and all parts solidify and cool more nearly at the same rate in spite of section differences.

In laying out a joint, it is helpful to inscribe circles in each part of the joint. The rate at which a point cools is roughly proportional to the radius of the circle that can be inscribed at the point. Good outlines for each type of section joint have been worked out by this method and by experience. The basic principle is to keep the inscribed circles as nearly equal as possible. In an L joint, for example, it is actually better design to round the corner and thin the casting out somewhat in the corner. Although the corner is thin, it is sound.

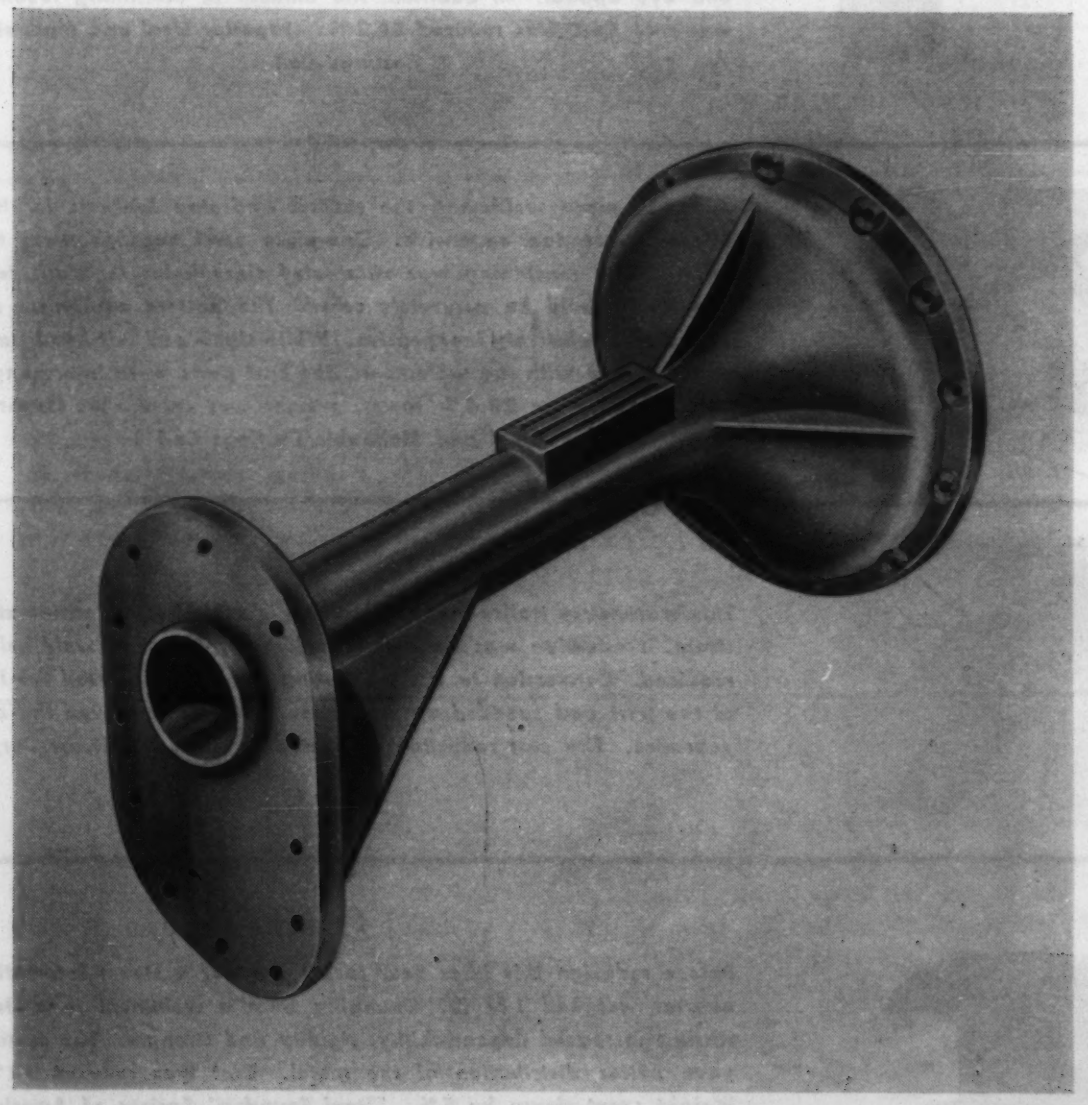
Some heavy isolated sections may be unavoidable. The best solution is to core these sections. The core reduces wall thickness, preventing hot spots. In cored sections, however, the size of the core cannot be too small in comparison with the mass of metal. If a core is too small, it may become fused into the metal.

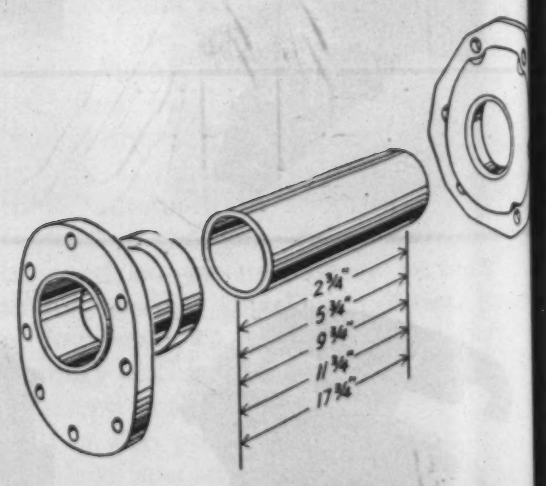
The engineer is sometimes tempted to increase the thickness of a section to give it more strength, without a corresponding increase in other sections. A better solution is to use reinforcing webs of smaller sections to back up parts that are heavily loaded. These webs, or brackets, must be thinner than the other sections since they are fed from these sections in casting. Ribs and brackets are also used to prevent distortion of large flat areas in cooling. The ribs solidify before the section and act as a reinforcement.

Deep pockets and small recesses are to be avoided. Molding production and cleaning are hampered, and hot spots are liable to be present because of the small amount of molding sand available to carry off heat from the bottom of such pockets.

Cores

Small holes are usually drilled rather than cored, especially when finished surfaces or close tolerances are required. Holes less than one-half the section thickness in diameter should not be cored, in any case, without consulation with the foundry. Complicated interior cores should be avoided. They add to production troubles and increase casting prices.





Cast steel drive spacers for tractors were expensive to cast in one-piece. Five sizes were required. Redesign to cast-weld construction cut weight and cost. (Steel Founders' Society of America.)

Tolerances and Allowances

Tolerances given as standard are based on the longest dimension of the casting. While length is not the only controlling factor, it is usually taken as a convenient basing point for design.

In addition to the tolerance on as-cast dimensions, an allowance must be made for metal to be removed from machined surfaces. This allowance increases with the size of the casting, but it also varies with design of the casting and position of the surface in the mold. A face that is uppermost in the mold must have a bigger allowance than a bottom face, because whatever sand is dislodged in pouring floats to the top of the casting.

The machine allowance should be considered in laying out the final part shape. A piece that would be possible to cast in its final shape is often difficult to cast with the machining allowance added to some faces. This allowance will often cause too large a variation in section thickness.

Castings vs. Other Forms

A steel casting can replace a forging economically and efficiently if die costs of the forging exceed casting production costs, or if too much machining is required after forging. Sometimes forging stock is also more expensive than casting steel for a given set of requirements. In general, a steel casting can be made in more complicated shapes than a forging. Light alloy forgings can also be replaced profitably when they cannot give the necessary compactness or fatigue strength.

Bolted and riveted assemblies can often be replaced by a steel casting to give a better looking piece of work. The casting may also be lighter and more rigid.

Many weldments can also be redesigned as steel castings. A weldment that is too intricate or must be produced in large numbers is a likely candidate. Excessive jig fixture costs also make a changeover from a weldment profitable. Many large weldments can most profitably be broken down into several wrought and or cast steel pieces which are welded together. This is a good fabrication method when the piece is too complex to be an economical wrought steel weldment, and is still impractical to cast.

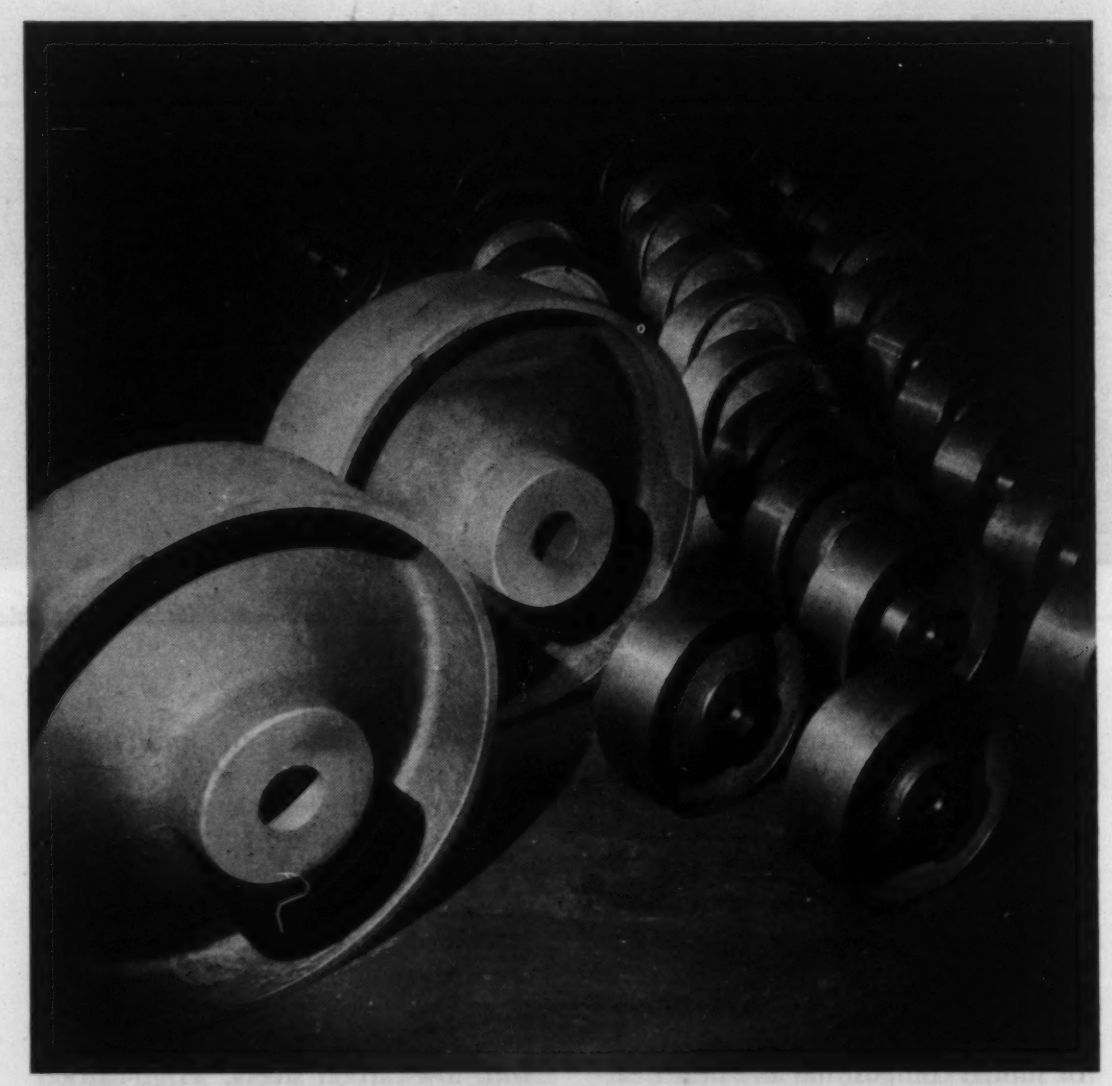
A casting can often be redesigned as a casting just as well as it can be made into a weldment or a forging. Simple lines, plain shapes and the elimination of nonessentials are the goals. Often a part is changed from casting to some other fabrication method when the fault is in the design rather than in the casting method itself.

Joining, Heat Treating and Inspecting

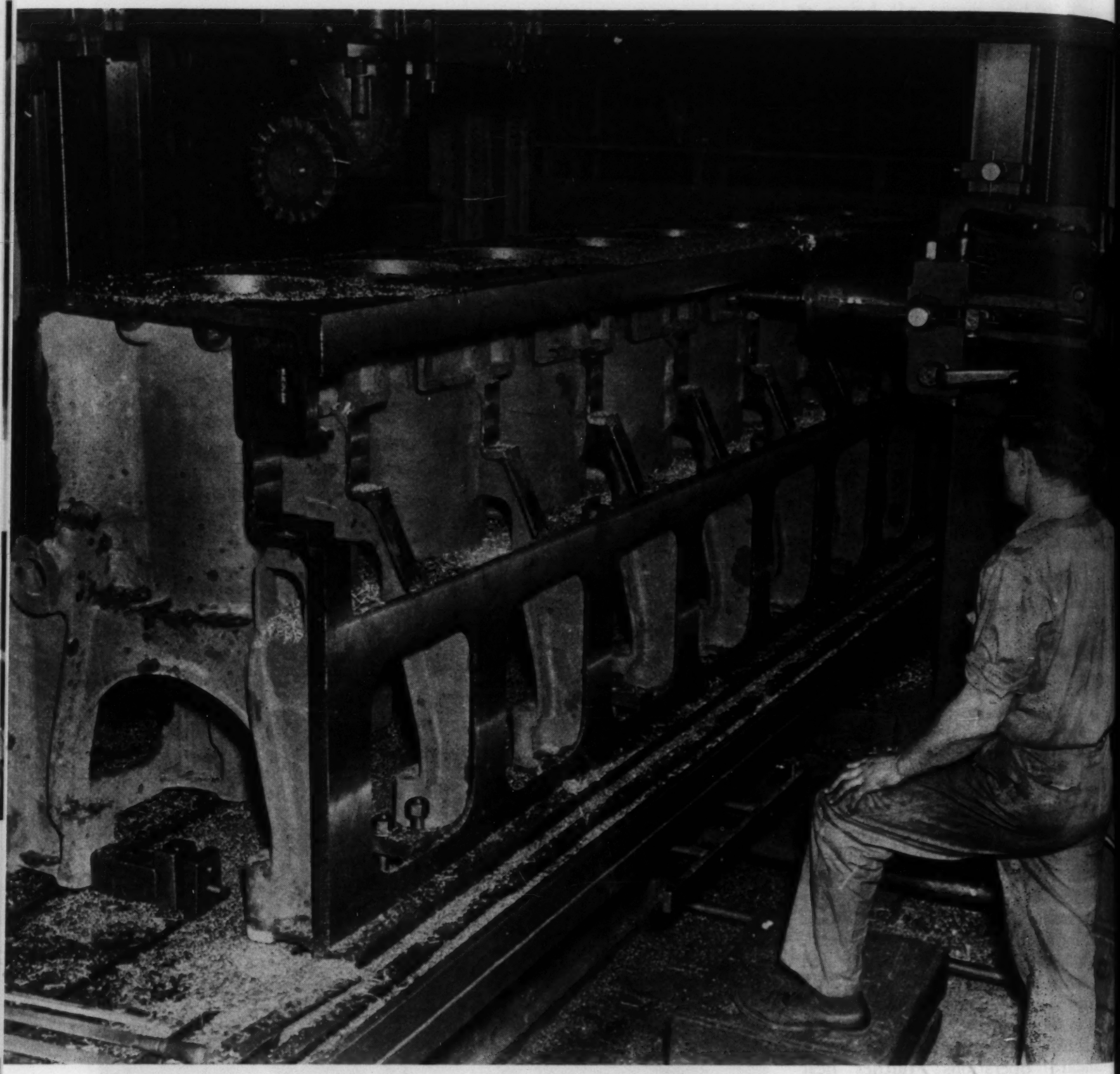
A steel casting is never shipped from a foundry in the as-cast condition. Gates and risers have to be cut off and stumps ground down to contour level on most pieces. The casting is pressure blasted to remove sand and cores and to improve the surface finish. After dimensions are checked, deficiencies can be corrected by straightening out-of-line members and by filling voids with weld metal. The casting can also be heat treated before it leaves the foundry.

In the customers plant, a steel casting is likely to be processed further. Machining, painting and plating are standard operations; further heat treatments can be used; and steel castings are often welded to each other and to wrought steel. Castings are tested, of course, in every stage of their manufacture.

Essentially, every processing method used on wrought steel can be and is used on steel castings. Some operations are more important than others industrially, however, and many techniques are modified to some extent when used on castings. Many of these processes are foundry problems and are not too interesting to anyone outside the foundry industry. A number of techniques and processes used



Alloy cast steel brake wheels are differentially hardened. (Sivyer Steel Casting Co.)



A large machine base casting being machined. (Steel Founders' Society of America)

to finish steel castings are of wide interest, though, and should be well understood by every prospective user and specifier.

Welding

A steel casting can be welded with the same facility as a wrought steel of similar composition and heat treatment. Procedures and principles used with wrought steels are applicable to steel castings.

A steel with less than 0.25% carbon and less than 0.50% manganese can be welded easily with no loss of ductility next to the weld. When the carbon content goes above 0.33%, the steel should be preheated. Almost every welded steel casting is stress relieved, although this is not essential with low-carbon steels. High-carbon and alloy steels, on the other hand, often need full annealing or normalizing after welding.

Repair welding is very commonly used to repair defects in steel castings. Surface blemishes are chipped, or flame washed, ground and welded. This is regular foundry procedure, especially on large, complicated castings which are difficult to produce perfectly. After proper heat treatment, a weld-repaired casting is perfectly sound.

Castings are finished by sand blasting to remove flash and rough edges. (Continental Foundry & Machine Co.)

Heat Treatments

A number of standard heat treating procedures have been developed for castings. These treatments should be performed by the foundry, if possible. The foundry is well equipped and experienced. In some cases, however, subsequent welding and machining require heat treatments in the customer's plant.

Annealing—Steel castings are annealed by (1) heating slowly (150 to 200 F per hr) to a temperature of about 1650 F for carbon steels, and possibly higher for alloy steels; (2) holding at the soaking temperature long enough for recrystallization and the correction of element segregation; and (3) cooling slowly in the furnace to 1000 F or less, then accelerating the cooling. Temperatures about 200 F above the transformation range are used because recrystallization is much faster. Small castings anneal rapidly, but large pieces take up to 10 to 12 hrs at temperature.

Carbon steel castings are fully annealed to refine grain structure and secure maximum stress relief. Alloy castings are usually only given a normalizing treatment. Full annealing increases ductility of the steel and lowers its tensile and yield strength. Impact strength also decreases. Annealing is used mostly on high car-

bon steels, large castings and low carbon electrical steels. It is also required when very low residual stresses are desired.

Normalizing—The same heating procedure—elevation above the transformation temperature and a soak at that point—is used in normalizing. In this treatment, however, the casting is cooled in still air directly from temperature. Both carbon and alloy steels are normalized. Strengths achieved are higher than those found in annealed steels. Normalizing is the least drastic of the hardening heat treatments.

Liquid Quenching—A more drastic hardening treatment is liquid quenching. This is done after the casting has been annealed or normalized. The piece is heated to a point about 100 F above the transformation temperature and held there long enough for the carbides to go into solution (30 to 60 min per in. of maximum cross section). From this temperature, the casting is quenched in oil or water.

A casting with various section thicknesses may be difficult to quench successfully. Heavy sections cool slower than light ones, and the light sections may crack. The best solution is to make the section thicknesses uniform. If this is impossible, special quenching methods involving shielding the thin sections from the liquid or time quenching are used.

Tempering—After normalizing or quenching, a casting is tempered. The piece is heated to temperatures from 400 to 1275 F, depending on the hardness and toughness desired, and held there for about 15 min to 1 hr per in. of section. When low temperatures (below 850 F) are used, the casting can be held at temperature longer. In practice, tempering points below 700 F are seldom used, and temperatures over 900 F are usual. In normalized steels, tempering under 1000 F has little effect on strength or ductility. Carbon steels are usually cooled in the furnace to some intermediate temperature, then air cooled to room temperature. Alloy steels subject to temper brittleness are usually cooled by water quenching directly from the tempering point. Castings with high hardness should be tempered immediately after quenching to prevent cracking.

Tempering removes the stresses set up by hardening. It also increases the ductility and impact resistance, and lowers the tensile and yield strength. The highest tempering temperature gives maximum ductility and toughness, the lowest, maximum hardness.

Special Treatments—There are a number of variations in quenching procedure. With a casting that might crack under a normal quench, the piece can be held in the oil or water until the largest section gets down to 500 F, then removed to let temperatures equalize, and finally tempered. Castings can also be heated by gas flames so that only particular portions are affected by the quench.

Inspection

Foundries test castings before shipment to the customer, who may also conduct systematic tests of his own. The tests used depend on the service required of the casting.

Coupons, or test blocks, are cast with the casting. These coupons are machined down to standard 0.505-in. tensile test specimens to give a good indication of the characteristics of the casting itself. Test pieces can also be chemically analyzed, and the microstructure of the steel can be studied.

For steel castings that are ordered in large quantities and must be interchangeable, templates are often used to check critical dimensions. Actual loading tests are made on other castings. Some customers even specify that castings chosen at specified intervals be broken. All these tests are similar to those done on wrought steel and other metal pieces.

As the temperature and strength requirements have increased, steel castings have been checked more closely for homogeneity to prevent failures due to structural defects in the metal. These tests are done on the casting itself and are usually performed on every piece when the requirements are unusually severe.

The most popular method of nondestructive testing is radiography. Magnetic particle testing is used to detect defects at or close to the surface. Another surface inspection technique is the use of penetrant materials. Supersonic testing is also done on a few large cast rolls. Almost all fluid-containing steel castings are pressure tested, even after radiographing.

References

Cast Metals Handbook. American Foundrymen's Assn., Chicago, Ill., 1944.

Briggs, C. W., Metallurgy of Steel Castings. McGraw-Hill Book Co., 1946.

Steel Castings Handbook. Steel Founders' Society of America, Cleveland, Ohio, 1950.

Acknowledgments

We gratefully acknowledge the help we have received from the personnel and publications of the following organizations:

American Foundrymen's Assn.
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Chicago Steel Foundry Co.
General Steel Castings Corp.
Lebanon Steel Foundry
Ohio Steel Foundry Co.
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp.
Steel Founders' Society of America
Superior Steel & Malleable Castings Co.
Texas Electric Steel Casting Co.
Unitcast Corp.
United Engineering and Foundry Co.
United States Pipe & Foundry Co.
Fronticepiece: courtesy of Mackintosh-Hemphill Co.

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Number 235

Materials Engineering File Facts

Materials Data Sheet

Manganese-Silicon and Manganese-Nickel-Chromium-Molybdenum Steels

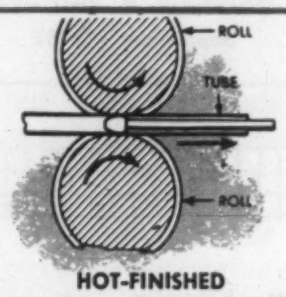
The steels of the 9200 series were developed originally as spring steels but have become popular in the manufacture of hand tools. Steels in the 9400 were among those developed to conserve alloying elements during the war as replacements for such steels as the 4100 series.

AISI TYPE	9255	9261	9440	9450
COMPOSITION, %	C 0.50/0.60 Mn 0.70/0.95 Si 1.80/2.20	C 0.55/0.65 Mn 0.75/1.00 Si 1.80/2.20 Cr 0.10/0.25	C 0.38/0.43 Mn 0.90/1.20 Si 0.20/0.35 Ni 0.30/0.60 Cr 0.30/0.50 Mo 0.08/0.15	C 0.43/0.48 Mn 1.00/1.30 Si 0.20/0.35 Ni 0.30/0.60 Cr 0.30/0.50 Mo 0.08/0.15
PHYSICAL PROPERTIES				
Density, lb/Cu In.	0.283	0.283	0.283	0.283
Thermal Cond, Btu/Hr/Sq Ft/Ft/F at 212 F	27	27	27	27
Coeff of Exp per F: 70–1200	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/Lb/F	0.10–0.11	0.10–0.11	0.11–0.12	0.11–0.12
Elect Res, Microhm-Cm @ 68 F	19	20	20	20
Magnetic Properties	Magnetic	Magnetic	Magnetic	Magnetic
MECHANICAL PROPERTIES				
Mod of Elast in Tension, Psi	29×10^6	29×10^6	29×10^6	29×10^6
Tensile Str, 1000 Psi:				
Normalized	132(1)	150(3)	115(5)	158(5)
Hard & Temp at 800 F	232(2)	258(4)	192(6)	210(7)
Hard & Temp at 1200 F	144(2)	148(4)	120(6)	132(7)
Yield Str, 1000 Psi:				
Normalized	90	80	74	110
Hard & Temp at 800 F	215	226	179	192
Hard & Temp at 1200 F	118	125	102	120
Elong in 2 In., %:				
Normalized	18	15	24	15
Hard & Temp at 800 F	9	10	15	12
Hard & Temp at 1200 F	20	18	23	20
Reduction of Area, %:				
Normalized	38	30	50	30
Hard & Temp at 800 F	21	30	56	48
Hard & Temp at 1200 F	42	40	67	57
Hardness, Bhn:				
Normalized	277	311	235	331
Hard & Temp at 800 F	477	514	388	429
Hard & Temp at 1200 F	285	311	248	285
Impact Strength, Izod, Ft-Lb:				
Normalized	12	5	48	8
Hard & Temp at 800 F	6	12	35	14
Hard & Temp at 1200 F	22	35	99	72
THERMAL TREATMENT				
Normalizing Temp F	1625–1675	1600–1650	1575–1625	1575–1625
Hardening Temp F	1500–1650	1500–1650	1500–1550	1500–1550
Tempering Temp F	To desired properties		To desired properties	
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1750–2175	1750–2175	1750–2175	1750–2175
Machinability Index (B1112 Steel = 100)	38	36	42	40
(180 Ft/Min—High-Speed Tool)	(68 ft/min)	(65 ft/min)	(76 ft/min)	(72 ft/min)
Weldability	The high carbon and silicon contents of these steels introduces difficulty in welding, which is, therefore, not recommended normally.		The high carbon content of these steels introduces difficulty in welding. With special techniques and electrodes, satisfactory arc welds can be made.	
CORROSION RESISTANCE	These steels are better than plain carbon steels in industrial atmosphere and about the same when continuously exposed to moisture. If salts are present, corrosion is increased. They are attacked readily by acids, but resistant to alkalis at ordinary temperatures.		These steels are better than plain carbon steels in an industrial atmosphere and about the same when continuously exposed to moisture. The corrosion rate is increased when salts are present. They are attacked by acids, but not by alkalis at ordinary temperatures.	
AVAILABLE FORMS	Billets, bars, forgings.		Billets, bars, forgings.	
USES	For coil and flat springs, lock washers, axes, chisels, hand tools, diesel engine connecting rod bolts, collets for machine tools.		Not in general use today. Formerly used for automotive, diesel engine and aircraft parts, bolts, chain, gears.	

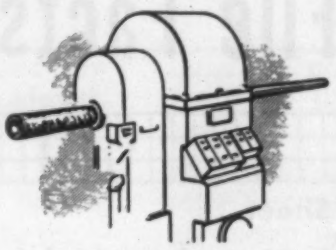
FOOTNOTES

(1) *Normalized at 1650 F.*
(2) *Normalized at 1650 F, reheated to 1625 F, quenched in agitated oil.*
(3) *Normalized at 1600 F.*
(4) *Normalized at 1600 F, reheated to 1575 F, quenched in agitated oil.*
(5) *Normalized at 1600 F.*
(6) *Normalized at 1600 F, reheated to 1525 F, quenched in agitated oil.*
(7) *Normalized at 1600 F, reheated to 1500 F, quenched in agitated oil.*

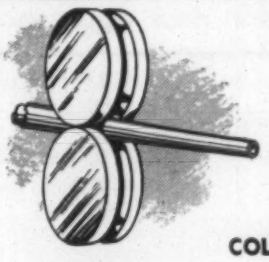
Prepared with the assistance of the Bethlehem Steel Co.



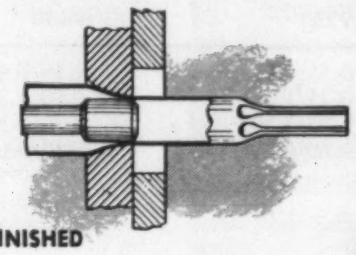
HOT-FINISHED
bears the scale formed during hot fabrication or heat treatment.



TURNED
machined, uniform O.D.

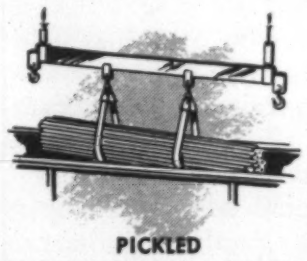


ROTO-ROCKED
Smooth surfaces, obtained by special sizing and finishing processes.

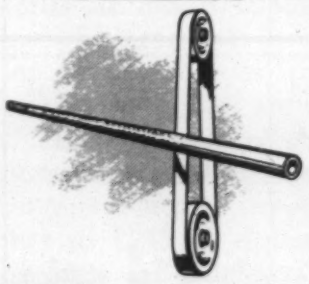


COLD DRAWN
Smooth, scale-free surface.

COLD FINISHED

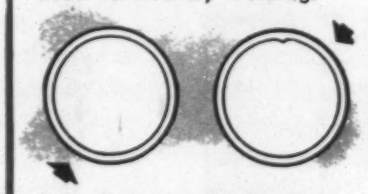


PICKLED
de-scaled by one of several solutions.



POLISHED
O.D. and/or I.D. polished to one of several specified degrees of smoothness.

FLASH-IN
ERW tubing which retains the bead formed by welding.



FLASH REMOVED
ERW tubing, bead-free.
Both available either as welded or normalized.

take a closer look at YOUR Finishing Time

You aren't taking full advantage of the time savings and cost economies in the machining and fabrication of hollow parts from tubing *unless you start with tubing having the* ***PROPER SURFACE FINISH.***

By specifying tubing having a surface finish keyed to your production methods, you take an important step toward reducing the time it takes you to make your finishing operations.

As a specialty tube mill, B&W supplies mechanical tubing in the variety of surface finishes illustrated.

Your choice should be influenced by your production facilities and consideration of the cost differentials among the several finishes.

In any case, remember that the tubing *you* can use is more than merely bar stock with a hole in it.

It can be delivered to you as a product ready for you to convert—in the shortest possible time and with least cost—into your finished product. Mr. Tubes—your B&W Tube Representative can help you select the tubing and finish most suitable for your specific end uses.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
General Offices & Plants
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

Sales Offices: Beaver Falls, Pa. • Boston 16, Mass. • Chicago 3, Ill. • Cleveland 14, Ohio • Denver 1, Colo. • Detroit 26, Mich. • Houston 19, Texas • Los Angeles 17, Cal. • New York 16, N. Y. • Philadelphia 2, Pa. • St. Louis 1, Mo. • San Francisco 3, Cal. • Syracuse 2, N. Y. • Toronto, Ontario • Tulsa 3, Okla.

B&W SEAMLESS and WELDED TUBES

TA-1690M

Materials Engineering File Facts

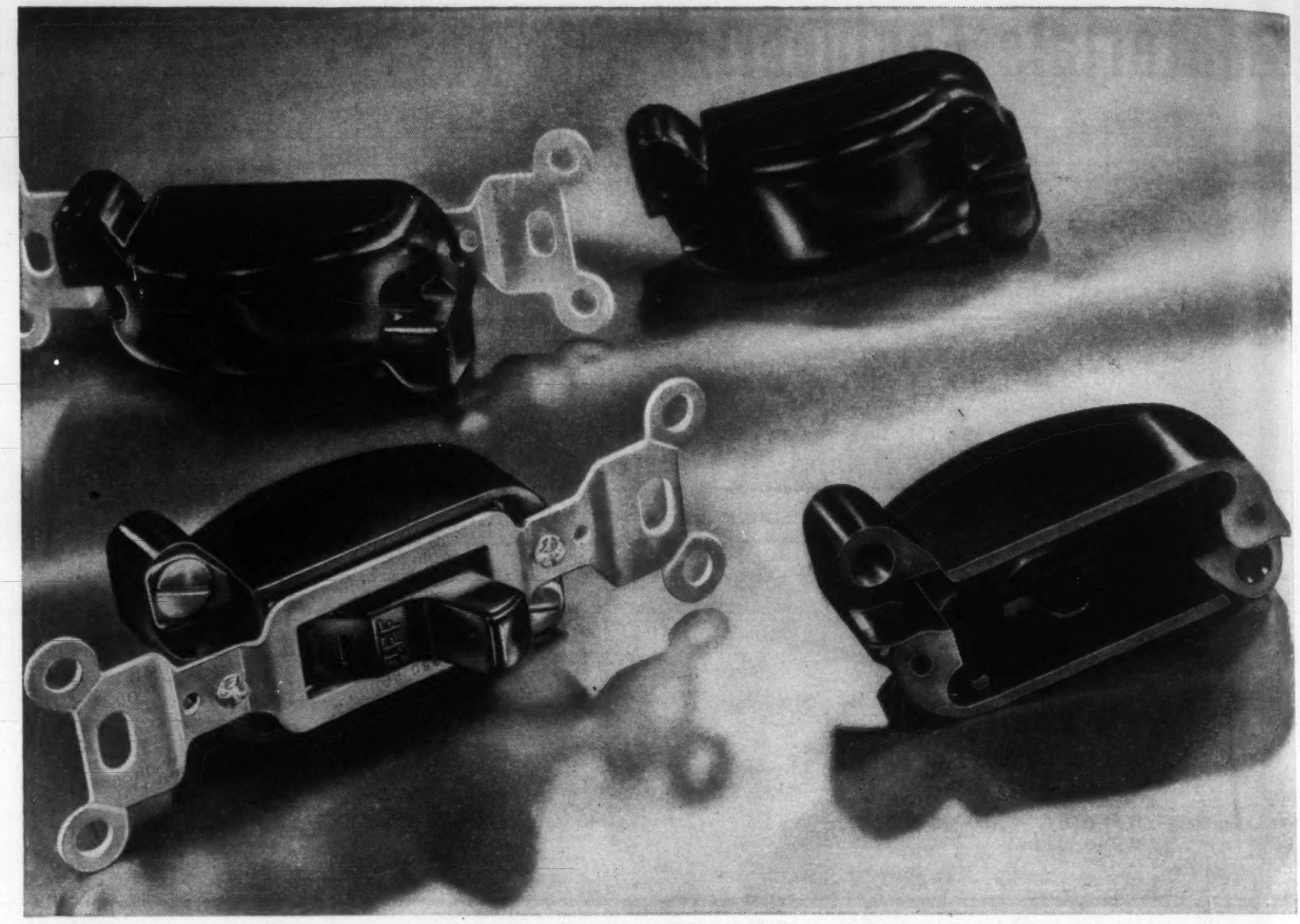
MATERIALS & METHODS
September • 1952
Number 236

Properties of Commonly Used Spring Materials

Material	Composition, %	Tensile Properties: Ult Str, 1000 Psi	Tensile Properties: Elastic Limit, 1000 Psi	Tensile Properties: Mod of Elasticity, Psi	Rockwell Hardness	Torsional Properties: Ult Str, 1000 Psi	Torsional Properties: Elastic Limit, 1000 Psi	Torsional Properties: Mod of Rigidity, Psi	Remarks
FLAT COLD ROLLED SPRING STEEL									
Watch Spring Steel	1.10–1.19 C 0.15–0.25 Mn	330–350	310–330	30×10^6	C50–55	Not used	Not used	Not used	Cold rolled and heat treated before forming. Mainsprings for watches and similar uses.
Clock Spring Steel	0.90–1.05 C 0.30–0.50 Mn	180–340	150–310	30×10^6	C40–52	Not used	Not used	Not used	Cold rolled and heat treated before forming. Clock and motor springs, misc., flat springs for high stress.
Flat Spring Steel	0.65–0.80 C 0.50–0.90 Mn	160–320	125–280	30×10^6	B70–85[1] C38–50[2]	Not used	Not used	Not used	Cold rolled, annealed or tempered. Misc., flat springs.
CARBON STEEL WIRES									
High Carbon Wire	0.85–0.95 C 0.25–0.60 Mn	200–250	160–210	30×10^6	C44–48	160–200	110–150	11.5×10^6	Cold rolled or drawn. High grade helical springs or wire forms.
Oil-Tempered Wire (ASTM A229-41)	0.60–0.70 C 0.60–0.90 Mn	155–300	120–250	29×10^6	C42–46	115–200	80–130	11.5×10^6	Cold drawn and heat treated before coiling. General spring use.
Music Wire (ASTM A228-41)	0.70–1.00 C 0.30–0.60 Mn	250–500	150–350	30×10^6	—	150–300	90–180	$11.5–12 \times 10^6$	Patented and cold drawn. Misc. small springs of various types—high quality.
Hard Drawn Spring Wire (ASTM A227-41)	0.60–0.70 C 0.90–1.20 Mn	150–300	100–200	29×10^6	—	120–220	75–130	11.5×10^6	Patented and cold drawn. Same uses as music wires but lower quality.
HOT ROLLED SPRING STEEL									
Hot Rolled Bars (ASTM A14-42)	0.90–1.05 C 0.25–0.50 Mn	175–200	105–140	28.5×10^6	C40–46	110–140	75–110	10.5×10^6	Hot rolled heavy coil or flat springs.
ALLOY STEEL SPRING MATERIALS									
Chromium Vanadium Steel SAE 6150	0.45–0.55 C 0.50–0.80 Mn 0.80–1.10 Cr 0.15–0.18 V	200–250	180–230	30×10^6	C42–48	140–175	100–130	11.5×10^6	Cold rolled or drawn. Special applications.
Silico-Manganese Steel SAE 9260	0.55–0.65 C 0.60–0.90 Mn 1.80–2.20 Si	200–250	180–230	30×10^6	C42–48	140–175	100–130	11.5×10^6	Hot or cold rolled or drawn. In some applications as lower cost material to replace chromium vanadium steel.

[1] *Annealed.*
[2] *Tempered.*

(Continued on page 143)



Mercury switch base molded of G-E 12493 general-purpose compound.

SWITCH

TO THIS NEW G-E MOLDING COMPOUND FOR GOOD-LOOKING, DIMENSIONALLY STABLE PLASTICS PARTS AT LOWER COST

Now you can obtain good-looking, dimensionally stable plastics parts *more economically* than ever before by specifying General Electric's general-purpose molding compound, G-E 12493. Here's why:

G-E 12493 helps your molder increase production and lower costs. Maximum output is maintained with this fast-curing, rigid-setting compound. Production is *steady*, too, because G-E 12493 pours cleanly and evenly. Waste is minimized, for its uniform bulk minimizes the possibility of overloading. Rejects are few, because of G-E 12493's easy flash release.

Ask your molder about the benefits to be obtained from a switch to this economical G-E compound. Or write direct for full details to General Electric Company, Section 124-4C, Chemical Division, Pittsfield, Massachusetts.

You can put your confidence in—

GENERAL ELECTRIC

124-4

NUMBER 236 (continued)

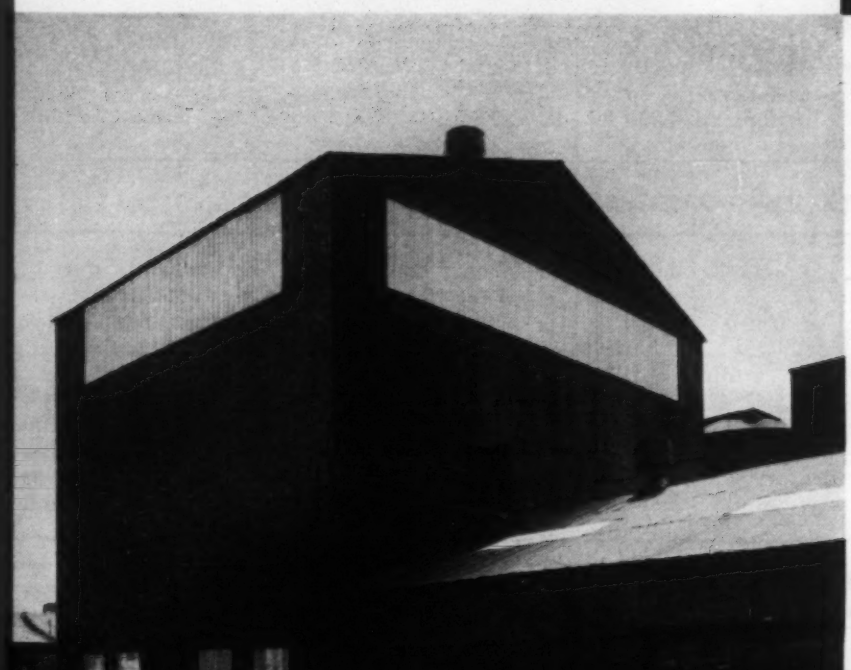
PROPERTIES OF COMMONLY USED SPRING MATERIALS

Material	Composition, %	Tensile Properties: Ult Str, 1000 Psi	Tensile Properties: Elastic Limit, 1000 Psi	Tensile Properties: Mod of Elasticity, Psi	Rockwell Hardness	Torsional Properties: Ult Str, 1000 Psi	Torsional Properties: Elastic Limit, 1000 Psi	Torsional Properties: Mod of Rigidity, Psi	Remarks
STAINLESS STEEL SPRING MATERIALS									
Type 302	17–20 Cr 7–10 Ni 0.08–0.15 C	160–330	60–260	28×10^6	C35–45	120–240	45–140	10×10^6	Cold rolled or drawn. Fair temperature resistance. Best corrosion resistance.
Type 420	12–14 Cr 0.25–0.40 C	170–250	130–200	28×10^6	C42–47	120–180	80–120	11×10^6	Cold rolled or drawn. Heat treated after forming. Resists corrosion when polished. Good temperature resistance.
NONFERROUS SPRING MATERIALS									
Spring Brass	64–72 Cu Rem. Zn	100–130	40–60	15×10^6	B90	45–90	30–60	5.5×10^6	Cold rolled or drawn. Used for corrosion resistance and electrical conductivity.
Nickel Silver	56 Cu 25 Zn 18 Ni	135–150	80–110	16×10^6	B95–100	85–100	60–70	5.5×10^6	Cold rolled or drawn. Better quality than brass. Used also for its color. Corrosion resistant.
Phosphor Bronze	91–93 Cu 7–9 Sn or 94–96 Cu 4–6 Sn	100–150	60–110	15×10^6	B90–100	80–105	50–85	6.2×10^6	Cold rolled or drawn. Used for corrosion resistance and electrical conductivity.
Silicon Bronze	2–3 Si Mn or Sn Rem Cu	100–150	60–110	15×10^6	B90–100	80–105	50–85	6.2×10^6	Cold rolled or drawn. Used as substitute for phosphor bronze for economy.
Monel	64 Ni 26 Cu 2.5 Mn 2.25 Fe	100–140	80–120	26×10^6	C23–28	75–110	45–70	9.5×10^6	Cold rolled or drawn. Resists corrosion. Moderate stresses to 400 F.
Inconel	80 Ni 14 Cr Rem Fe	140–175	110–135	31×10^6	C30–40	95–120	55–80	11×10^6	Cold rolled or drawn. Resists corrosion. High stresses to 650 F.
K-Monel	66 Ni 29 Cu 2.75 Al 0.90 Fe	160–180	115–145	26×10^6	C33–40	105–125	65–85	9.5×10^6	Cold rolled or drawn. Precipitation hardenable. Resists corrosion. High stresses to 450 F.
Z-Nickel	98 Ni, Cu, Mn, Fe, Si	180–230	130–170	30×10^6	C36–46	120–150	60–90	11×10^6	Cold rolled or drawn. Precipitation hardenable. Resists corrosion. High stresses to 550 F.
Beryllium-Copper	98 Cu 2 Be	160–200	100–150	$16–18.5 \times 10^6$	C35–42	100–130	65–95	$6–7 \times 10^6$	Cold rolled or drawn. Precipitation hardenable. Corrosion resistant. Good electrical properties.

Courtesy of The Associated Spring Corp.

— for Quality with Economy . . .

EXTRUDED PLEXIGLAS

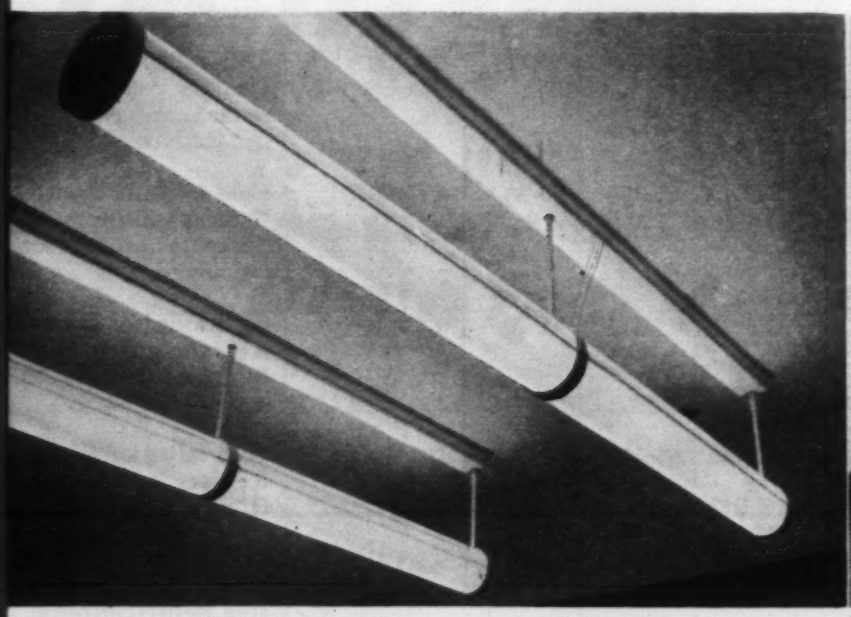


Industrial sidewall glazing, with extruded white translucent PLEXIGLAS, corrugated to match standard industrial siding.

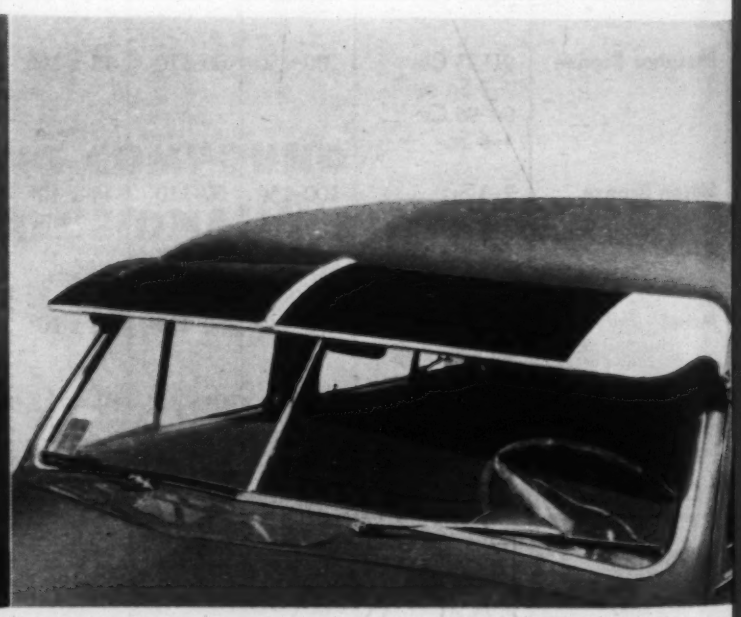
Continuous extrusion—using PLEXIGLAS extrusion-grade molding powder—can be a fast economical method of producing, at low cost, parts having uniform cross sections.

That's why designers are specifying extruded PLEXIGLAS for automobile sun visors, signs, lighting fixtures, counter dividers in retail stores, display fixtures . . . and for glazing prefabricated buildings and industrial structures where window breakage is a problem. These are only a few of the many existing and potential applications.

Extrusion Grade PLEXIGLAS molding powder does more than insure efficient production. Extruded sections have excellent gloss and clarity or color, and the resistance to heat, weather, and breakage for which PLEXIGLAS acrylic plastic is noted.



Totally enclosed lighting fixtures with extruded clear and white translucent PLEXIGLAS semicylinders.



Automobile sun visor with extruded green PLEXIGLAS sections, ribbed on upper surfaces.

(PLEXIGLAS *extrusions illustrated are produced by Sandee Manufacturing Company, Chicago, Illinois.*)

PLEXIGLAS *is a trademark, Reg. U. S. Pat. Off. and in other principal countries of the Western Hemisphere.*

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Representatives in principal foreign countries

New Materials and Equipment

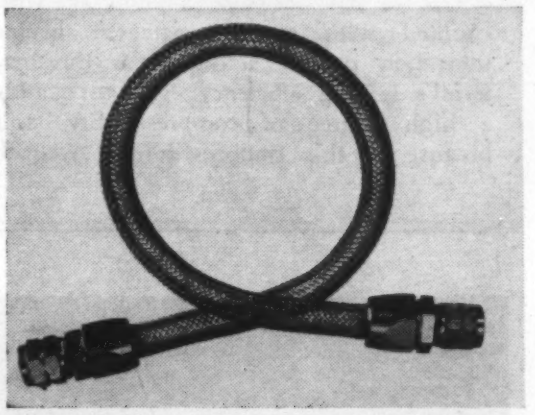
Plastic Tubing Reinforced with Stainless Steel

Developed to meet the demand for a chemically resistant, translucent, nontoxic, flexible tubing and hose for high pressure applications, the new Tygon flexible plastic tubing offered by *U. S. Stoneware Co.*, Akron 9, Ohio, has a triple wire and a stainless steel outer braid.

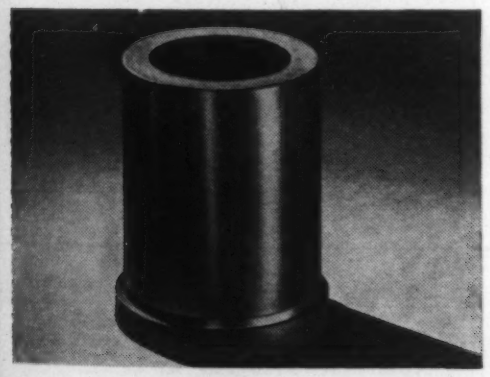
With this braided stainless steel reinforcement, Tygon tubing absorbs vibration more readily and does not crack, leak or break under working pressures up to and including 300 psi. Because of the flexibility of this tubing, less footage is required than with rigid tubing, fewer fittings are necessary, and no special tools are required for installation. It is also translucent, permitting visual inspection of flow and simplifying cleaning.

The tubing is stocked in two sizes: ¼-in. i.d. and ⅜-in. i.d. It is available in six standard formulations and in running or fitted lengths. All fittings are stainless steel. The ¼-in. i.d. fittings can be field applied. The ⅜-in. i.d. crimped fittings are factory applied. Other sizes are available on special order.

Recommended for the high pressure transmission of virtually any liquid, gas or semi-solid, the tubing is particularly effective in the handling of highly corrosive materials which must be protected from contamination.



This stainless steel braided tubing is chemically resistant, translucent and nontoxic.



The use of Carbolube in the manufacture of this bushing is said to eliminate lubrication problems

Metal Impregnated Graphite Has Good Bearing Properties

A new product for bearings or wearing parts that is said to help eliminate difficult lubrication problems has been announced by *The Carbone Corp.*, Boonton, N. J. Carbolube is graphite or carbon impregnated with babbit, copper, cadmium or silver. When used in the manufacture of bearings, bushings, or any wearing parts, oil or other lubrication is unnecessary since self-lubrication is an inherent property of the finished product.

Carbolube parts are used in air compressors, textile and printing machinery, aircraft parts, and motors. They are used on marine equipment and fluid meters where parts are inaccessible. They are used in baking equipment, and chemical and food equipment where cleanliness is important and oil fumes are undesirable.

The new product is made with a vacuum-pressure process that is said to assure uniformity of structure. It is available in sizes up to 10-in. dia, and in almost any shape or form. Bearings or parts can be made economically to specifications in small or large quantities.

Oil-Free Dry Bearing Material Withstands Temperatures up to 500 F

Samples of Rulon, a recently developed low-friction bearing material, are now being offered for testing commercially by *Dixon Lubricating Saddle Co.*, Bristol, R. I. The new material requires no lubrication and is said to outperform currently available plastics, metallic and other bearing materials.

As finally developed, Rulon is a substance slippery throughout, from outer skin to inner core. No sealed-in lubricant nor lubricant impregnation is required. It contains no oil, no graphite or other substances usually referred to as lubricants. Rulon's success as a bearing depends entirely on its ability to resist heat and on its inherently low coefficient of friction. The Dixon bearing application consists of a half-sleeve bearing which runs on a cast iron or hardened steel shaft. The shaft has a speed range of 100 to 200 rpm, and the bearing has loads of approximately 175 psi.

Tests indicate that Rulon will operate satisfactorily without lubricants under greater loads and speeds than are normal in spinning operations. Withstanding temperatures up to 500 F, the material is chemically inert and cannot be attacked by any process material. For commercial testing outside the maker's own field of primary interest, Rulon is available in small quantities of rod stock in diameters from ¼ up to 1- by ⅛-in. increments.

New Materials and Equipment continued

Gasketing Material Offers Improved Performance and Dependability

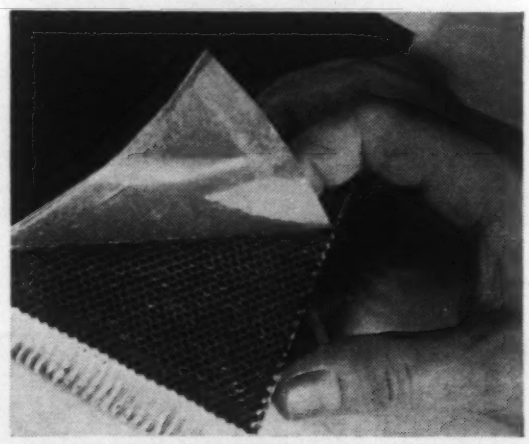
A new and basically different type of gasket material, Accopac, has been announced by *Armstrong Cork Co.,* 6207 Arch St., Lancaster, Pa. In applications calling for plant fiber gaskets, the material is said to offer improved performance and dependability and, according to the company, it seals so effectively that in many cases it promises to replace more expensive gasket stocks.

Use of an adequate amount of cork coupled with a new patented beater saturation process accounts for the material's sealing efficiency. The cork adds a high degree of compressibility, and because of this compressibility, Accopac works well on stamped or light flanges as on rough, heavy joints. In lightweight construction it conforms to normal irregularities without distorting flanges between bolts, and on rough, heavy flange surfaces, it fills ordinary imperfections to provide a tight, dependable seal.

Effective in heavy flanges, the material will withstand flange loads up to 100,000 psi without damage. Conventional fibers, on the other hand, often rupture at approximately 25,000 psi.

The saturants used in Accopac materials are nonvolatile and nonextractable. They will not be lost in service through the action of fluids. Therefore, an Accopac gasket will not shrink, dry out or leak. Dimensional stability is further insured by the uniformity of the latex coating on both the fibers and the cork particles.

The new beater saturation process used in making the material can deposit much larger amounts of rubber on the fibers and cork particles than is possible with any other known method, according to company reports. The rubber coating is uniform and accurately controlled. Resulting sheets are uniformly tight and impervious. For example, a gasket of Accopac CN-707 easily holds air at 2000 psi.



This aluminum honeycomb is now offered in the new 1/8-in. cell size for use in sandwich structures.

Aluminum Honeycomb Material Offered in New Cell Size

Production of Hexcel aluminum honeycomb in the new 1/8-in. cell size for use in sandwich structures has been announced by *Hexcel Products Co.,* distributors for *California Reinforced Plastics Co.,* Oakland, Calif. The product is to provide substantially 100% bond area, increasing skin-bond strength and bond-weight efficiency.

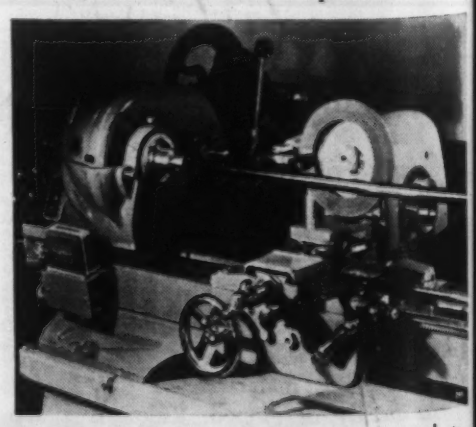
According to the company, the new size core material greatly simplifies bonding, since sufficient adhesive can be deposited on honeycomb with only one pass through glue spreader. As a direct result, only one drying cycle is needed. At the same time, use of the 1/8-in. product results in a less expensive glue line, since a smaller amount of adhesive is needed in priming. Lighter bonding tapes or films can also be used. The new product is available in 0.001-in. nominal gage, with density of 4.6 lb per cu ft, and in 0.0015-in. nominal gage, density 6.7 lb.

Abrasion Tester for Cylindrical Parts

Taber Instrument Corp., 109 Goundry St., North Tonawanda, N. Y., has announced a new abrasion testing machine for rating the wear resistance of protective finishes—black oxidized or electroplated coatings, extruded plastic and enamel applied to aircraft, ordnance and metal furniture tubing, and other cylindrical parts or test pieces.

The accompanying photo shows a 34-in. rifle barrel being tested to determine the amount of wear from handling the metal part will withstand before the blue oxide finish is worn thin, resulting in corrosion of the part. The test is performed by placing the gun barrel between two driving centers with the test surface in contact with the abrading head. This abrading head can be adjusted lengthwise of the barrel to any position within its range. Pressure of the abradant against the test surface is applied by a floating dead weight load system, which compensates for minor inaccuracies of the test part. The resulting wear is comparable to a gun being handled under field service conditions.

The Model No. W-3981 Cylinder Abrasion Tester is fully adjustable to take cylindrical specimens from 1/2-in. to 6 in. in dia and 8 to 36 in. in length. The width of the wear track is normally 1 in.; however, the face of the abrading medium can be narrowed to wear a track only 1/2 in. in width where required. Abrasion resistance is reported as the number of wear cycles the surface will withstand before penetration of the protective finish permits corrosion to take place. The end point for corrosion resistance is determined with an indicator solution. A visual end point can also be used by comparing with a standard. Wear cycles are indicated by an electric counter at left of operator.



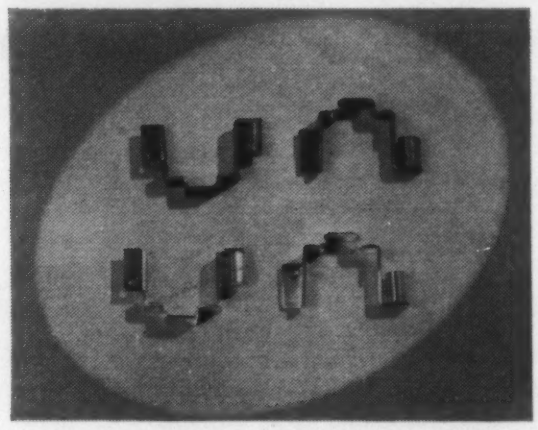
Here a rifle barrel is being tested to determine the amount of wear it will withstand before corrosion results.

Alkaline Stripper Dissolves Tin, Lead and Tin-Lead Alloys

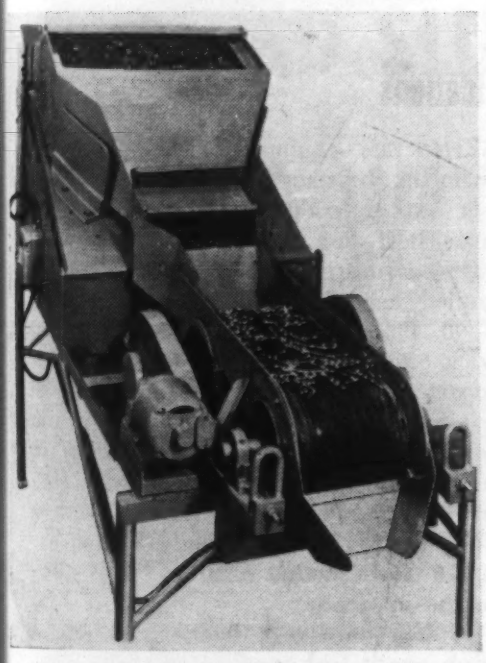
A new alkaline chemical for the rapid dissolving of tin, lead and tin-lead alloys has been announced by *Enthone, Inc.*, 442 Elm St., New Haven. The material is used in water in a concentration of 1 lb per gal, and the mixture is heated to 160 to 180 F.

According to the company, the stripper will rapidly remove tin, lead and tin-lead electrodeposits, heavy solder and hot dipped coatings. Due to the fact that it is alkaline in nature, there is no attack upon base metals, such as copper, brass, bronze, steel and stainless steels. The material is kept in steel or stainless steel containers and does not deteriorate with age.

Stripping action on both tin and lead is fast, and thicknesses of the order of 0.005 to 0.010 in. are removed in 1 hr. The product is said to be suitable for removing solder from torch or iron soldered pieces as well as hot dipped soldered articles, and unlike acids does not cause any dimensional change in the base metal.



Here, upper pieces are in the as-soldered condition. Lower pieces are completely cleaned of solder with no attack on base brass.



This unit can be used either as a mechanical or magnetic separator.

Mechanical-Magnetic Separator for Ferrous and Nonferrous Parts

A combination magnetic separator, especially designed to separate parts from Roto-Finish abrasive chips where both ferrous and nonferrous parts are processed using Roto-Finish methods, is currently being offered by *Roto-Finish Co.*, 3700 Milham Rd., Kalamazoo, Mich. The unique feature of the Roto-Finish MMG 34-12 is that the magnetic and mechanical separating mechanisms are interchangeable on the portable frame. As a result, the unit can be used either as a mechanical or magnetic separator.

Operation is claimed to be simple. A hoist pan containing the mixed parts and processing media is placed on the incline loading support of the separator. When used for mechanical separations, the mixed mass passes over a motor-driven, agitated separator. Separation is made as the oversize parts are discharged from the top of the screen, while processing chips go through the screen and discharge into a hoist pan below. The amount of agitation is controlled by a variable stroke adjustment. Screens are available in mesh sizes of 1/16 in. to 1½ in., and correspond to Roto-Finish chip sizes. The screen size measures 34-by 27-in.

For magnetic separations, the magnetic separating unit replaces the agitated screen unit. Parts and chips pass over a magnetic pulley. Parts are separated magnetically and then conveyed to a container, while the chips fall into a hoist pan below.

The separator is recommended for use in conjunction with the original company processes used to grind, deburr, descale, britehone and color all types of metal parts.

Aluminum Paint Bonds Well to Many Metals

A new ready-mixed aluminum paint that becomes permanently bonded to almost any metal surface upon subjecting the painted metal to heat of 500 to 1600 F, has been announced by *Sheffield Bronze Paint Corp.*, 17814 Waterloo Rd., Cleveland 19. Originally developed to protect and decorate metal surfaces where extreme heat is required, the paint will add a protective and decorative finish to furnaces, pipes, boilers, ovens and other metal surfaces withstanding 1600 F. The greater the heat, the more permanent is said to be the bond as the paint alloys itself to the metal surface with the application of heat. It maintains its brilliance and will not crack, chip or peel.

Numerous applications for Super-Hot have been found in industry. Employing its adhesive quality, a manufacturer can use it in a heat plating process for bright permanent finishes on metal objects at important economies. Thermocoupling action sponsored by the application of heat in excess of 800 F to a metal object painted with the paint is said to make the object impervious to most ordinary solvents. This is due to the transition of Super-Hot from a periferal coating of paint to an aluminum glaze that is an integral exterior of the painted object.

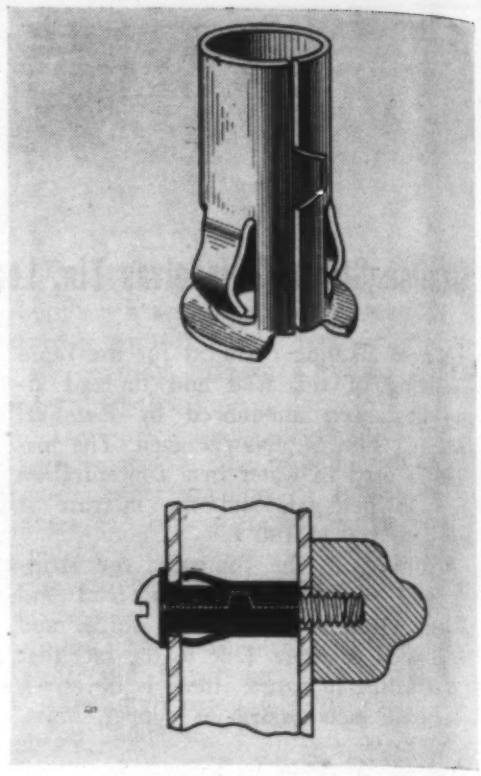
The new paint can be brushed, sprayed or dipped and air dries within 30 min., after which time heat can be applied. Although best results are obtained when application is made on clean, dry surfaces, the paint can be applied to rusty, moderately greasy or oily surfaces.

New Materials and Equipment continued

Spacer Clip for Parallel Metal Panels

Spacing of parallel metal panels without buckling has been achieved with a new tubular type Speed Clip announced by *Tinnerman Products, Inc.,* Box 6688, Cleveland. Used more specifically for spacing panels of drawers on kitchen cabinets, office furniture and similar articles, the clip is inserted through a hole in a drawer liner, and is held in a self-retaining position. A machine screw is then inserted into the clip through the outer panel where the screw engages the threads in the drawer handle. In this application the clip has replaced an expensive special screw provided with a shoulder to act as a spacer.

The clip also speeds production by guiding the screw directly to the outer panel hole. Made of heat treated spring steel, it is 23/64 in. in dia and ¾ in. long and takes an 832 screw. The inner panel hole diameter is 0.281 in.



This tubular type speed clip speeds production by guiding the screw directly to the outer panel hole.

This Model RSZ50 Rivet Cooler has a 5 cu-ft capacity.

Sub-Zero Cabinets for Variety of Applications

Revco, Inc., Deerfield, Mich., has announced new sub-zero cabinets used for shrink fits, seasoning gages, testing and preparing rivets for aircraft applications. Model RSZ50 Rivet Cooler is furnished with 90 rivet cannisters made of steel 2 in. in dia and 7½ in. long, arranged in six racks each holding 15 cannisters. The cooler is designed to operate efficiently at temperatures as low as—30 F. Sturdy, all steel cabinet construction is sealed air and water tight, inside and out. The unit is equipped with high density, thick, nonsettling Fiberglas bats, providing highest insulating efficiency.

The Sub-Zero Models SZH15 and SZH65 are equipped with Sub-Lid to maintain constant temperature throughout storage compartment and to minimize heat loss during usage. Temperature control is adjustable for any controlled temperature down to as low as —90 F for Model SZH15 in normal room temperature, and —80 F for model SZH65. A temperature of —95 F for SZH15 and —85 F for SZH65 can be obtained by continuous running in normal room temperature. Model SZH15 has a 1.5 cu-ft storage capacity with a 15½ reach—in depth, while SZH65 has a 6.5 cu-ft storage capacity with 18½ reach—in depth.

Resistance Spot Welding and Soldering Machine Speeds Production

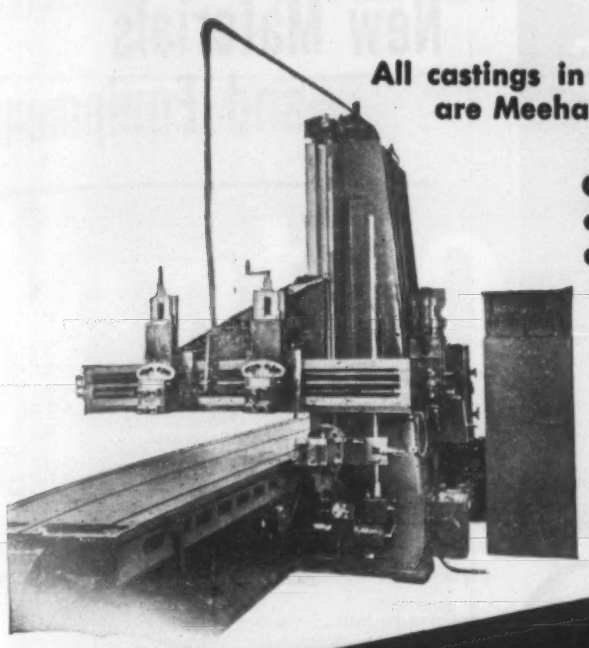
Availability of a new resistance spot welding and soldering machine has been announced by *Joyal Products, Inc.,* 56 Belmont Ave., Newark 3. Designed to speed production, cut cost and eliminate shrinkage in the manufacturing of instruments, the unit is proving valuable to the manufacturer of small, metal products. It solders or welds in less than a second larger and heavier parts than those handled by Model 1000 and 2000.

The machine is also said to silver solder, soft solder and spot weld precious and dissimilar metals. It spot welds steel parts up to 3/16 in. in thickness; spot welds copper to bronze, copper-to-copper up to 0.040 in. and brass-to-brass up to 0.080 in. It will also solder brass up to ¼ in. in thickness as well as sterling silver and other precious metals.

The new unit features a quick adjusting device for pressure control and length of electrode travel for positive soldering and welding. The set-up time for the various production operations is simple and rapid; electrodes are especially designed for each job. An automatic cut-off timer regulates soldering time and heat control, with 11 adjustments determining correct heat for the job.

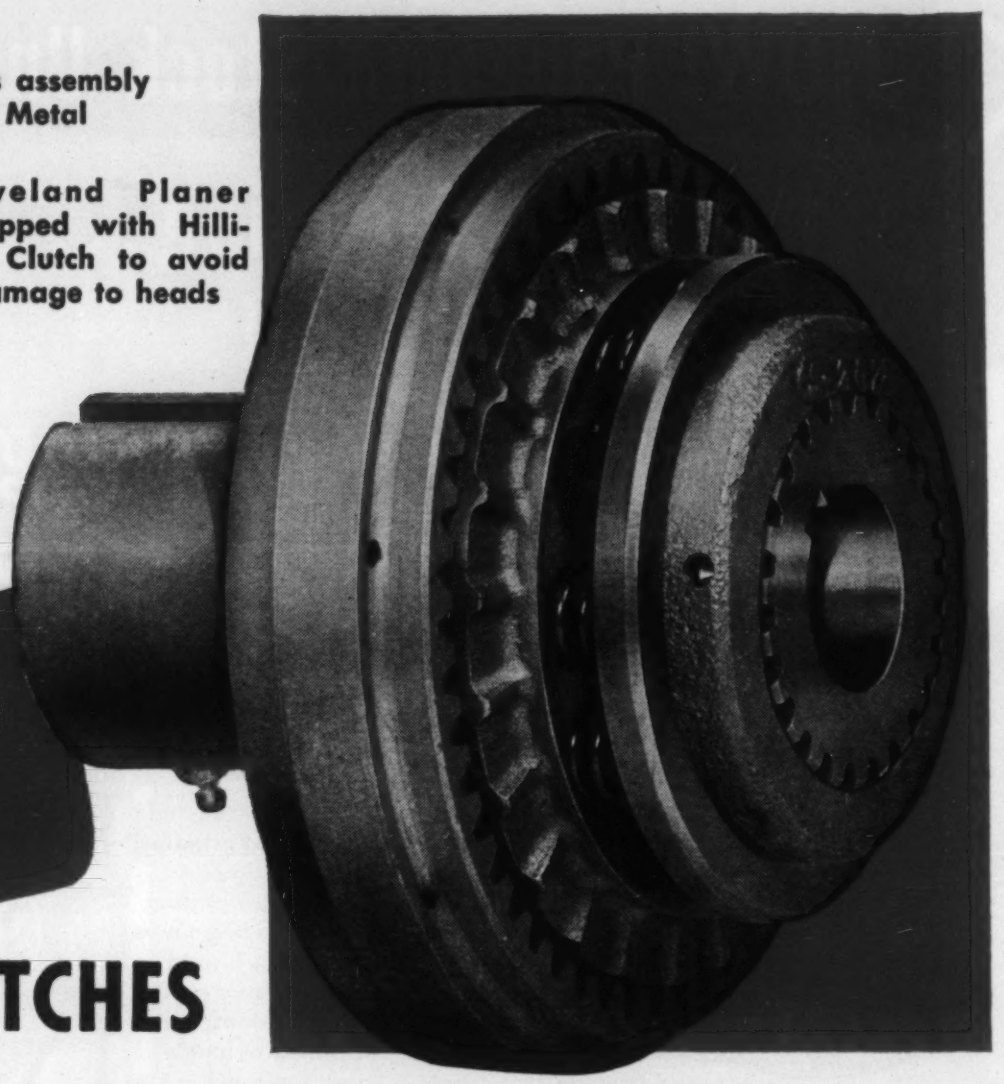
Particularly effective in soldering additional elements to an assembly, the machine leaves no pitting marks. It has found an excellent application in the production of fractional horsepower motors. Previously, slip rings were soft-soldered; now they are welded, eliminating soft soldering, shrinkage, and increasing production. Another application is the high temperature soft soldering of commutators at 800 F. With the use of this machine production is said to be increased about 200% because it eliminates the flooding of solder around the segments which before had required a time-consuming extra manual operation to remove.

(More News on page 150)



All castings in this assembly are Meehanite Metal

Cleveland Planer equipped with Hilliard Clutch to avoid damage to heads



FOR DURABILITY IN SERVICE

HILLIARD SLIP CLUTCHES

BUILT WITH MEEHANITE CASTINGS

The Hilliard Corporation—Elmira, New York, manufacture a line of all-purpose slip clutches (Fig. 1) for use in equipment requiring precise control of tension or power applied to a driven machine and in connection with safety devices and load limiting mechanisms. As an example, planers such as shown in Fig. 2 incorporate Hilliard clutches to protect the heads and crossrails against damage in case of obstruction.

Such clutches obviously require component castings which can provide without fail three definite characteristics—namely:

1. **High tensile strength**
2. **Resistance to heat deterioration**
3. **Maximum wearing qualities**

Hilliard designers specify Meehanite castings for all cast parts of this clutch on the basis of experience and the sure knowledge that these properties will be secured regularly.

In addition the use of Meehanite castings gives an assurance of uniformity, ready machinability, and a high freedom from casting defects. Thus production flows are steady and efficient and Quality of the product high.

For facts about how Meehanite castings can improve *your* product, reduce losses and speed production, write for Bulletin #35—"Meehanite Castings Serve All Industry".

Take *YOUR* Casting Problem To A MEEHANITE FOUNDRY

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry	Providence, Rhode Island
Compton Foundry	Compton, Calif.
Continental Gin Co.	Birmingham, Alabama
Crawford & Doherty Foundry Co.	Portland, Oregon
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Empire Pattern & Foundry Co.	Tulsa, Oklahoma
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Hardinge Company, Inc.	New York, New York
Hardinge Manufacturing Co.	York, Pennsylvania
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Lincoln Foundry Corp.	Los Angeles, California
E. Long Ltd.	Orillia, Ontario
Otis Elevator Co., Ltd.	Hamilton, Ontario
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Sonith Industries, Inc.	Indianapolis, Ind.
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

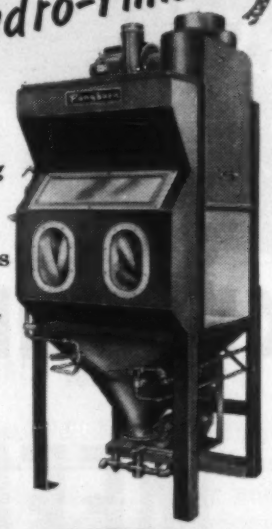
MEEHANITE® NEW ROCHELLE, N. Y.

NOW! Pangborn Stock Units for Blast Cleaning... Dust Control... Precision Finishing

Blast Clean with this Portable Unit!

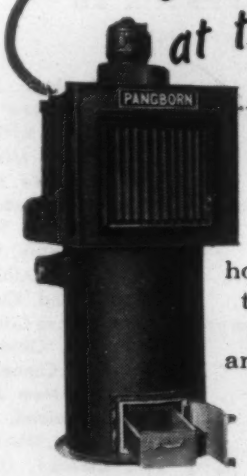
Ideal for maintenance and many other jobs, including removal of rust, dirt, scale, etc. Economically cleans large objects like tanks, bridges, structural work before painting. Six sizes, stationary or portable, from . . . . **$170.00** and up.

Speed Polishing with Hydro-Finish!



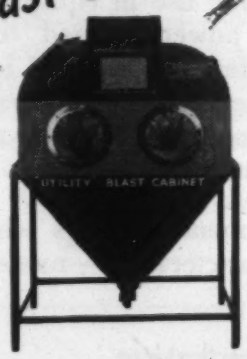
Removes scale and directional grinding lines . . . prepares surfaces for plating and holds tolerances to .0001"! Liquid blast reduces costly hand cleaning and finishing of molds, dies, tools, etc. Models from **$1410.00** and up.

Stop Dust at the Source!



Pangborn industrial type Unit Dust Collectors trap dust at source. Machine wear is minimized, housekeeping and maintenance costs reduced. Solves many grinding and polishing nuisances and material losses. Models from **$286.00** and up.

Clean Small Work in this Blast Cabinet!



Ideal for producing smooth, clean surfaces on pieces up to 60" x 36" in size. Cleans metal parts, removes rust, scale, dirt, grime, paint, etc., in a few seconds. Saves money all year 'round. Models from . . . **$319.00** and up.

Look to Pangborn for the latest developments in Blast Cleaning and Dust Control equipment

Pangborn MAIL COUPON FOR DETAILS

Check for more information

- ☐ Blast Cleaning Cabinets
- ☐ Blast Cleaning Machines
- ☐ Unit Dust Collectors
- ☐ Hydro-Finish Cabinets

PANGBORN CORP., 1700 Pangborn Blvd., Hagerstown, Md.

Gentlemen: Please send me more information on the equipment I've checked on the left. To be used for_____

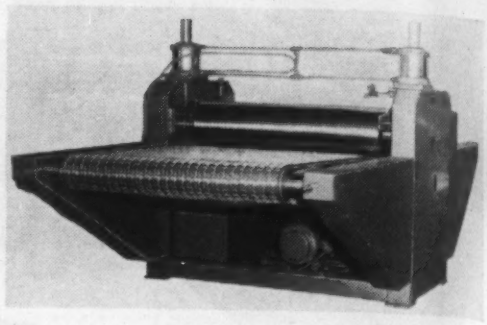
Name . . . . . .

Company . . . . . .

Address . . . . . .

City . . . . . Zone . . . . State . . . . . .

New Materials and Equipment



Roller Coater Applies Compound to One or Both Sides of Metal

A new line of roller coaters said to set a new high in functional efficiency and in time and labor saving, has been announced by The *Union Tool Corp.*, Warsaw, Ind. The new model is equipped with three sets of rolls and with automatic infeed and off-bearing conveyors. Rubber nip rolls convey the workpiece from infeed conveyor through a set of brush rolls for cleaning and then through a set of hardened steel coating rolls. Doctor rolls, controlled by a calibrated handwheel with micrometer adjustment, accurately gage the thickness of the compound coating.

Pressure on the coating rolls is applied by two 6-in. dia air cylinders which will develop 28 times the line pressure. Pressures from 0 to 160 lb are said to be achieved. The air cylinder circuit is equipped with regulator, gage, oiler and filter.

The excessive pressure behind the hardened steel coating rolls serves two important functions. It provides a deburring action on the metal workpiece and, at the same time, supplies the pressure necessary to press the compound effectively into the pores of the metal. This increases die life, decreases scrap, and results in substantial savings in compound due to the thin, even, controlled coating of film.

Silicone Resin Has Good Bonding Strength

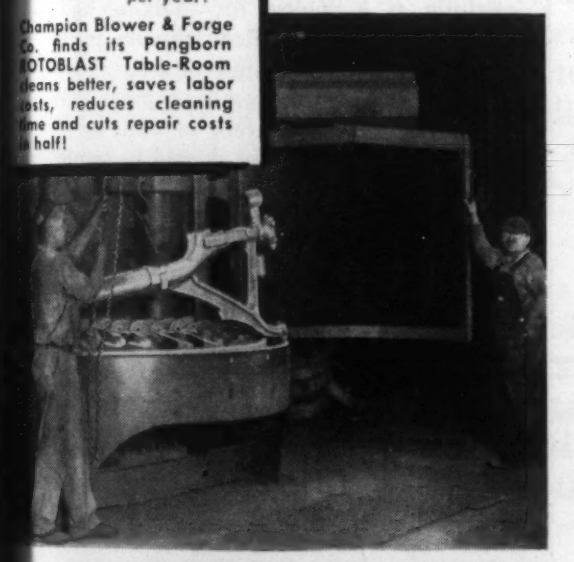
A new silicone resin for Class H electric insulation that maintains its bonding strength and hardness at temperatures 50 to 90 F above any known commercially available silicone resin has been developed by the Chemical Div., *General Electric Co.*, Pittsfield, Mass. Desig-

Jobbing Foundries!

Want to Save $40,000 $5,000 $11,000 ?

How ROTOBLAST works for you:

SAVES LABOR with push-button operation
SAVES SPACE because machines are compact
SAVES TIME by cleaning more loads per day
SAVES POWER since no compressor is needed
SAVES TOOLS because all scale is removed



Saved: $5,452 per year!

Champion Blower & Forge Co. finds its Pangborn ROTOBLAST Table-Room cleans better, saves labor costs, reduces cleaning time and cuts repair costs in half!

Saved: $40,944 per year!

ROTOBLAST Table-Room cleans the entire output of General Foundries in 40% less time than previous method and practically eliminates breakage of delicate castings.

Saved: $11,102 per year!

Lewiston Foundry, where this before-and-after picture was taken, reports: "ROTOBLAST gets hard-to-clean castings really clean . . . cleaning time cut 87½% . . . costs reduced 55%."

Install a Pangborn ROTOBLAST® Table-Room!

Here are actual figures showing money saved in one year by jobbing foundries when a Pangborn ROTOBLAST LK Table-Room was put to work: Champion Blower & Forge Co., Lancaster, Pa., saved $5,452 on labor and maintenance. A $150 *per day* reduction in breakage plus labor savings netted General Foundries, Milwaukee, Wis., a total of $40,944! Lewiston Foundry, Lewiston, Pa., saved $11,102 on labor alone! In each case, just *one* LK Table-Room was responsible!

Hard to believe? We've got the facts! And we're ready to show you how Pangborn ROTOBLAST Table-Rooms set new records for low-cost, high-quality blast cleaning. From small castings of any shape, up to heavy castings of 5000 lbs., five feet long, thirty inches high, Pangborn Table-Rooms clean faster, better and cheaper!

And remember: there's a modern ROTOBLAST unit to do a better job at far lower cost, no matter what you clean—large or small castings, fragile or intricate castings, or any combination. Write for details. Ask for Bulletin No. 221 (Table-Rooms) or No. 214 (all ROTOBLAST equipment). Address: PANGBORN CORPORATION, 1700 Pangborn Blvd., Hagerstown, Md.

OVER 28,000 PANGBORN MACHINES SERVING INDUSTRY

Look to Pangborn for the latest developments in Blast Cleaning and Dust Control equipment

Pangborn

BLAST CLEANS CHEAPER
with the right equipment for every job

"Standard"

Serves Manufacturers Who Use All Shapes and Sizes of

MECHANICAL STEEL TUBING

SIZE AND THICKNESS CHART

of Electric Weld Tubing for Mechanical Use

TUBE DIAMETER *O.D. SIZE	MAXIMUM WALL		MINIMUM WALL	
	DECIMAL	B. W. GAUGE	DECIMAL	B. W. GAUGE
1/2"	.065"	16	.028"	22
5/8"	.065"	16	.028"	22
3/4"	.065"	16	.028"	22
7/8"	.083"	14	.028"	22
1"	.109"	12	.028"	22
1-1/8"	.109"	12	.028"	22
1-1/4"	.134"	10	.028"	22
1-3/8"	.134"	10	.028"	22
1-1/2"	.148"	9	.035"	20
1-5/8"	.148"	9	.035"	20
1-3/4"	.148"	9	.035"	20
1-7/8"	.165"	8	.035"	20
2"	.165"	8	.035"	20
2-1/4"	.180"	7	.035"	20
2-1/2"	.203"	6	.035"	20
2-3/4"	.203"	6	.035"	20
3"	.220"	5	.049"	18
3-1/4"	.220"	5	.049"	18
3-1/2"	.238"	4	.049"	18
3-3/4"	.238"	4	.049"	18
3-7/8"	.238"	4	.049"	18
4"	.238"	4	.049"	18
4-1/4"	.250"	3	.065"	18
4-1/2"	.250"	3	.083"	16
4-3/4"	.250"	3	.083"	14
5"	.180"	7	.083"	14
5-1/2"	.180"	7	.083"	14

*Intermediate sizes within the range indicated can also be manufactured. Please consult us for sizes not listed.

Manufacturers requiring tubing for civilian or defense production prefer "Standard's" Electric Weld Steel Tubing for many reasons! "Standard's" Electric Weld is produced in one of the most versatile and complete mills of its kind in the world. "Standard's" 33 years of specialized tubing "know-how", and monthly production of millions of feet of stainless and carbon steel tubing, in wide range of sizes and gauges, assure you of utmost satisfaction. No problem of tolerance, precision or severest application for mechanical, structural, or pressure tubing is too difficult.

STAINLESS STEEL TUBING
⅛" to 3" O.D. . . .028 to .095 wall

ABOVE CHART COVERS ROUND CARBON STEEL TUBING . . .

•

EQUIVALENT SQUARES, RECTANGULARS AND SPECIAL SHAPES ARE ALSO AVAILABLE.

THE STANDARD TUBE CO.

Detroit 28, Michigan

Welded Tubing — Fabricated Parts

STANDARDIZE with STANDARD — It Pays

New Materials and Equipment

nated as SR-98, the new product is said to permit greater design flexibility in motors, transformers and generators where vibration is a factor. Because of its excellent bonding strength and lack of flow at elevated temperatures, coils and other rigidly mounted components are held more securely in position than with former silicone resins.

Having good solvent and abrasion resistance over a wide temperature range, SR-98 forms an exceptionally hard, tough, insulating film. When used to treat glass cloth, asbestos paper or cloth, and mica products, it produces a more rigid type of product.

The new resin is supplied at 50% solids content and is light amber in color. It can be thinned with xylene, toluene, or petroleum spirits. No catalyst is required. SR-98 has also been used successfully as a vehicle for caulking and sealing compounds. Filled with an inert material such as mica dust or talc, 25 to 50% by weight, the resulting paste can be applied between layers of coil insulation. A heat stable seal is said to result after curing.

Compound Removes Prints from Metal

A new compound, Gulf No-Rust FPR (finger print remover) has been developed by the *Gulf Oil Corp.*, 722 Gulf Bldg., Pittsburgh 30. The need for such a product has been evidenced by the experience of manufacturers of parts and products with dimensional tolerances and surface smoothness of a few ten thousandths of an inch, and in many cases to a few microinches, finding the product becoming useless or inoperative due to very slight corrosion or even heavy staining.

After several years of research, Gulf has provided a solution to the problem in the form of its new compound, which is said to be capable of removing damaging fingerprints and other similar corrosive materials from fine finished surfaces and establishing a corrosion preventive film sufficient to protect the part between manufacturing operations and during temporary storage.

The compound contains a highly effective and potent rust preventative. It can be applied to steel, brass, copper, cadmium, magnesium, zinc and other metal surfaces by dipping, flooding or spraying. It is recommended for application to

Arwood's 3 highly efficient precision casting plants

The plants of Arwood are planned and built to be efficient, to manufacture economically and to deliver the utmost in quality and finish. The personnel is carefully selected and trained to produce to Arwood's exacting standards of manufacture.

These facts about Arwood production are of importance. The design and die division, for instance, has made literally thousands of intricate moulds and has the experience to answer the most difficult design problems. The cam illustrated is a typical example. Arwood, too, is able to cast in both ferrous and non-ferrous metals to tolerances of ± .002 to ± .005. Whether a quantity is large or small flexibility in design makes it economical. Service is another factor. Resident sales engineers throughout the country are able to give you valuable information quickly.

Here are a few practical results of the Arwood operation. A part was designed and made three times stronger than it had been made before at a 90% saving. Another application combined seven parts into one. And many times, after careful study, precision casting parts were made that could be made no other way. Arwood has accepted many challenges and because of engineering skill, perfection in tooling, complete control and production efficiency, has been able to meet each one.

If you have a production problem, why don't you write Arwood. Our engineers have worked in many industries and have the "know-how" that can be helpful to you. For important information about the versatility of precision casting, write for our booklet, "Alloy Selection and Design for Investment Castings," and visit our booth, No. 1758, at the National Metal Exposition in October in Philadelphia.

ARWOOD

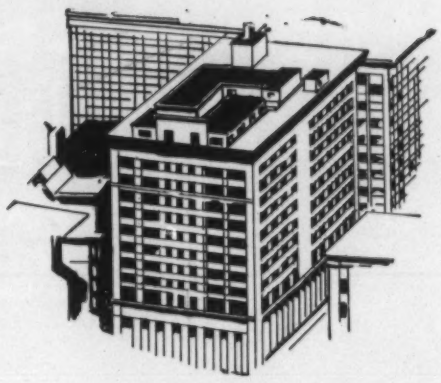
PRECISION CASTING CORP.

74 WASHINGTON STREET • BROOKLYN 1, N. Y.

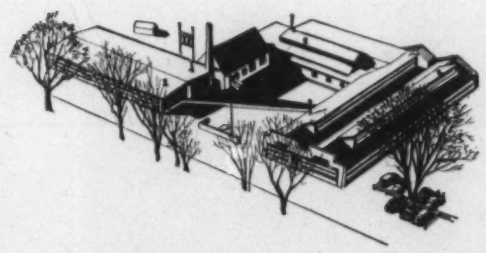
1

2

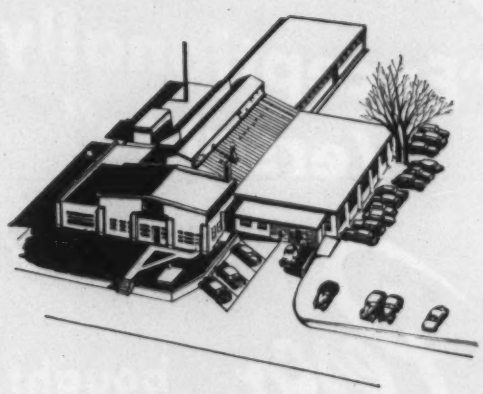
3



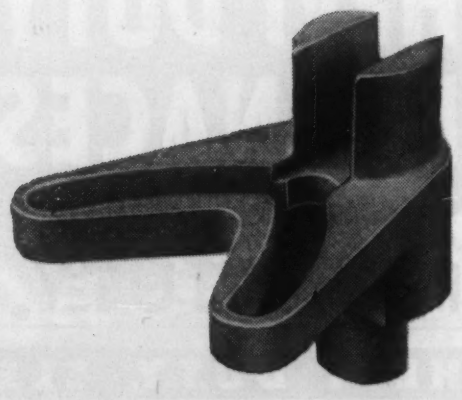
General offices and plant, Brooklyn, N. Y.



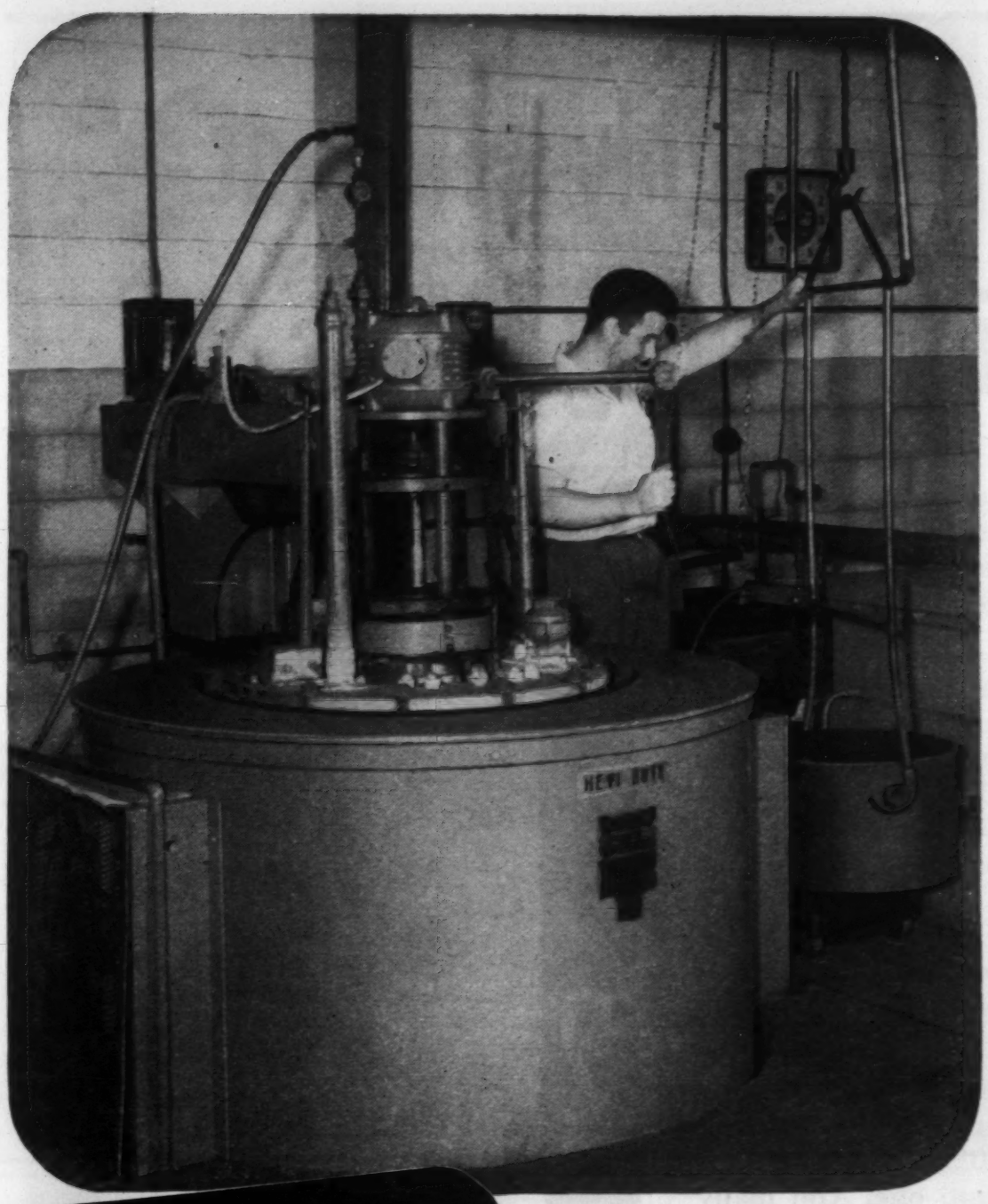
Tilton, N. H., plant



Groton, Conn., plant



Stainless steel release cam made by Arwood at a 58% saving



"Exceptionally Versatile" . . . that's why Pesco bought HEVI DUTY FURNACES

"We use our rugged Hevi Duty furnaces for carburizing, nitriding, hardening and normalizing parts for jet engine pumps," says Russ Fike chief metallurgist of the Pesco Products Co. "We can carburize one load and nitride the next by simply changing the atmosphere. Operating costs are at a minimum due to low ammonia consumption when nitriding, and our maintenance costs are negligible."

Learn how the versatile Hevi Duty vertical retort furnace can solve your production problems, write for your copy of bulletin HD-646 today.

HEVI DUTY

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces . . . Electric Exclusively

• *Dry Type Transformers* • *Constant Current Regulators*

New Materials and Equipment

freshly machined metal surfaces of fine finish and close tolerances, such as those on anti-friction bearings, instruments and precision products. This thin film print remover will displace water films by preferential wetting of the metal surfaces. Precision parts or surfaces wet with cutting or grinding compounds are cleaned and protected by immersion in the compound. Perspiration residues are removed by dissolution; further contamination is prevented by establishing a rust and corrosion protective film, giving temporary protection to the metal surfaces.

High Precision Abrasive Cutting Process for Hard-to-Work Materials

Cutting by means of a high-velocity stream of gas-propelled abrasive particles, the newly developed S. S. White Industrial Airbrasive Unit offered by *S. S. White Industrial Div.*, 10 E. 40th St., New York 16, is said to provide a fast, accurate method of doing a number of high precision operations, including controlled removal of metallized films from glass and ceramics, drilling thin sections of hard-to-work materials, cutting extremely hard or brittle materials, etching, light deburring and polishing. The unit is expected to find important applications in jewelry manufacturing and in the electronics, glass, ceramics and precision metal working industries.

In operation, the unit directs a gas-propelled abrasive stream against the work surface through a sintered tungsten carbide nozzle. As it leaves the nozzle, the stream travels at approximately 1100

Houghto-Quench

the fastest quench this side of water!

. . . provides the safe, sure quenching needed for "LEAN ALLOY" steels!

Use Houghto-Quench to meet your most critical quenching needs. We developed this stable oil to give you all three of these essentials that heat treating low alloy steels demand:

1. A faster quench through the critical zone
2. Full hardness to meet high physicals safely
3. Uniform quenching of *any* steel at *any* temperature

Ask the Houghton Man to show you why it pays you to specify Houghto-Quench—particularly today. Or write to E. F. Houghton & Co., Philadelphia 33, Pa., for full information.

DO YOU HAVE OUR HANDBOOK ON QUENCHING?

Contains complete information on this important phase of heat treating. We'll gladly mail a copy, without charge, to anyone engaged in metal processing.

HOUGHTO-QUENCH
. . . a product of

E. F. HOUGHTON & CO.
PHILADELPHIA • CHICAGO • DETROIT • SAN FRANCISCO

Ready to give you on-the-job service . . .

This is a high chrome alloy — 24% chromium and 12% nickel — an excellent alloy for meeting the conditions imposed when handling molten aluminum. As you can see the casting is approximately 6 inches in diameter — not a big casting as many Duraloy products go but indicative of what we can do in the way of small castings.

Our experience in this business of high alloy castings goes back to 1922 and we also pioneered work in the centrifugally cast high alloys which we inaugurated back in 1931. So we have much to offer those requiring chrome-iron, chrome-nickel and nickel-chrome castings. Plenty of experience, skilled metallurgists and foundrymen, modern testing and analytical facilities, and one of the most up-to-date and fully equipped high alloy foundries in the country.

We'll be glad to help (1) in the design of the part you need to produce the strongest casting and (2) to advise in the alloying elements to produce the most durable casting.

THE DURALOY COMPANY

Office and Plant: Scottdale, Pa. • *Eastern Office:* 12 East 41st Street, New York 17, N.Y.

Detroit Office: 23906 Woodward Avenue • Pleasant Ridge, Mich.

Atlanta: J. M. TULL Metal & Supply Co. Chicago: F. O. NELSON 332 S. Michigan Avenue San Francisco: JOHN D. FENSTERMACHER 1241 Taylor Street

METAL GOODS CORP. Dallas • Denver • Houston • Kansas City • New Orleans • St. Louis • Tulsa

New Materials and Equipment

ft per sec and is only 0.018 in. in dia. As a result, extremely fast and accurate cuts can be made.

The process is claimed to have a number of advantages over standard rotary cutting tools:

Cutting action is accomplished without the usual increase in temperature and without pressure and vibration ordinarily experienced with other cutting methods. This has been found to be of particular significance when working on materials such as germanium, whose physical or electrical properties might be affected by heat and shock.

Another advantage is that there is no direct contact of a tool with the work. This eliminates dimensional variations that might set in due to wear of the cutting tool or by surface irregularities in the work.

Despite the ease with which it cuts hard and brittle surfaces, the unit has practically no effect on resilient or soft materials, such as rubber, cloth and certain types of plastics. Likewise, it will not damage skin tissue, should the operator accidentally put his hand in front of the abrasive stream. This selective cutting effect has been found most helpful in removing metallized films coated on a relatively soft base.

Normally, a specially processed aluminum oxide powder is used as the abrasive. For certain applications which require a lighter abrasive, a classified Dolomite—a mixture of calcium and magnesium carbonates—can be supplied. Standard commercial grades of abrasive are not suitable. Any dry inert gas can be used as the propellant. Carbon dioxide is generally preferred, however, because of its ready availability.

Fine-Precision Reticles Offered

The *United States Testing Co., Inc.*, 1415 Park Ave., Hoboken, N. J., is currently offering super-precision reticles which are available in either standard or custom design to suit every requirement.

Specific uses for which the new reticle is said to be ideal are: for checking fiber diameter and size gradation in textile testing; for checking of angles or for checking of either standard or complex forms in engineering; for gram structure and pearlite studies in metallurgy; for fire control instruments, such as range finders, gun sights and field binoculars in ordnance equipment. In

Hayes at CBS-HYTRON

"We are very happy with the results from our Hayes furnaces," says Larry Meinerth, Hytron heat-treating supervisor

IN THE BEAUTIFUL new plant of CBS-Hytron at Danvers, Massachusetts, de-gassifying of radio and TV tube parts has been set up as an automatic, electronically controlled process. A key factor in making this practical is the dependability of Hayes "Certain Curtain" furnace equipment.

FAMOUS HAYES "HUMPBACK" FURNACES GIVE BETTER THAN 4-TO-1 HYDROGEN ECONOMY

Complete process is 100% automatically controlled

Hayes Inclined-Hood design enables these furnaces to operate on 125 c.f.h. of dissociated-ammonia hydrogen. Operating temperature is 700-800°C.—treating nickel, copper, nickel plated steel, with cooling to room temperature. "Our atmosphere savings are very substantial," notes Mr. Meinerth, "and we are getting more uniform work of ideal cleanliness."

Work goes direct from degreasing to furnaces, passing through special drying units shown here

For the BEST in Electric Heat Treating Equipment, Request Catalog 112

C. I. HAYES INC. 80 BAKER ST., PROVIDENCE, R. I.

Manufacturers of Electric Furnaces Since 1905

ELECTRIC (CERTAIN CURTAIN) FURNACES

Whether you slap-trowel it...

or gun it...

Slap-troweling a long lasting Blazecrete lining on a boiler wall.

You reduce refractory maintenance costs with J-M BLAZECRETE

Labor costs for refractory maintenance are materially reduced when you build and repair high-temperature equipment linings with Johns-Manville's new hydraulic setting Blazecrete.*

Just mix Blazecrete with water—as you would mix ordinary concrete—then apply it by gunning or slap-troweling. It goes on fast . . . without laborious ramming or tamping . . . *and it lasts.* Even in foundries—where refractories take a real beating—Blazecrete linings have proved that they can resist spalling, withstand slagging action, and remain unaffected by rapid changes in temperature.

Three types of Blazecrete are available. All harden on air curing, do not require pre-firing. They can be fired or left standing indefinitely. Each of the three types described below, is furnished as a dry mix . . . can be stored safely for use as needed.

3X BLAZECRETE

For temperatures through 3000F. Unusually effective for heavy patching, especially where brickwork is spalled or deeply eroded. Excellent for building and repairing forge furnace linings, lime kilns, burner blocks—and for lining ladles in ferrous and non-ferrous foundries.

STANDARD BLAZECRETE

For temperatures through 2400F. For building new and repairing old refractory linings. Makes repair work easier and less costly. Can be used by boiler manufacturers to replace fire clay tile in wall construction. Suitable for use in combination with 3X and L. W. Blazecrete.

L. W. BLAZECRETE

For temperatures through 2000F. An *insulating* refractory . . . light in weight, low in thermal conductivity. For building new linings and repairing old. Adaptable and economical for many other applications.

For further details, send for Brochure RC-28A. It also tells about Blazecrete's companion material, Firecrete*... the hydraulic setting castable refractory for making special shapes and linings. Just write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

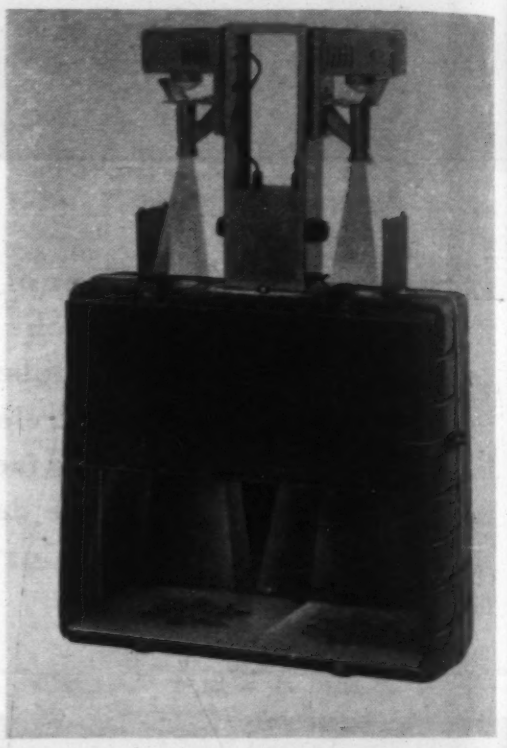
*Reg. U.S. Pat. Off.

Johns-Manville BLAZECRETE

REFRACTORY LININGS

New Materials and Equipment

addition, the reticles are useful in the medical field, in nucleonics and for theodolites, transit levels and micrometers. Protractors and dust counting reticles are also available.



Plastic Replica Surface Comparator Offers Greater Flexibility

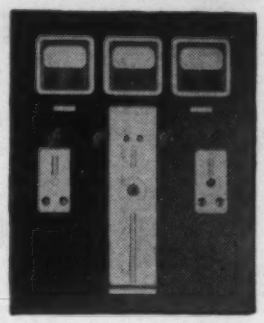
Greater flexibility in use, increased portability and more pleasing appearance are features of the new Faxfilm surface comparator, Model BL-122, now offered by The *Brush Development Co.*, 3405 Perkins Ave., Cleveland 14. Faxfilm is the method of surface study in which a clear plastic replica of a surface is made in about a minute and projected in a microprojector to show minute details of surface condition with marked three-dimensional effect.

The new comparator provides comparison of two Faxfilm replicas at 30-dia magnification. Its principal uses include comparison of work specimens with standard finishes in surface roughness inspection, the comparison of finishes obtained in machinability studies, and comparisons of surface changes in wear and life tests.

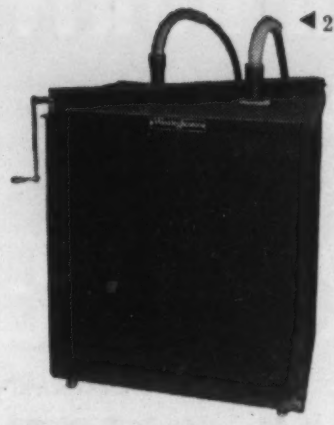
25- by 12-in. at the base and 22½ in. high, the unit weighs less than 30 lb. Included are an accessory and file case carried in the base of the unit.

(More News on page 161)

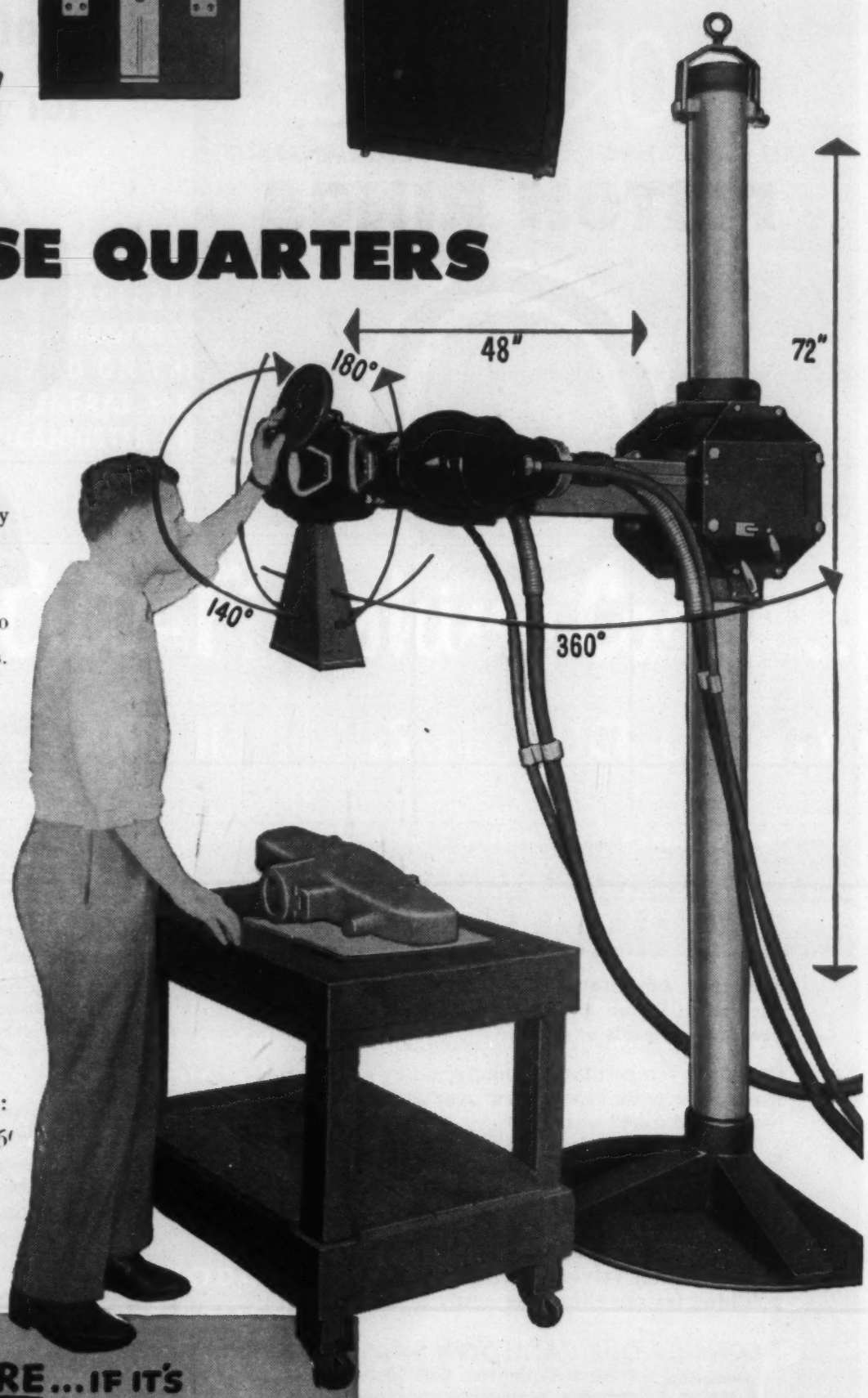
The Westinghouse 250 kv control ▶



◀ 250 kv constant potential transformer



WHEN IT'S *Tough* AT CLOSE QUARTERS



Tubestand features easy, counter-balanced movements with positive locks

For heavy-duty inspection problems in limited space, nothing beats the dependable Westinghouse 250 kv industrial tubestand X-ray unit. High X-ray output plus maximum maneuverability, means inspection savings on large, cumbersome parts. This unit will help to solve many of your toughest inspection problems.

Examine the 250 kv unit—note these outstanding features which guarantee high quality radiographs:

- Ease of operation
- X-Actron milliamperage control
- Constant potential for highest X-ray output
- Direct kilovoltage reading
- Load pre-set
- Fine focal spot X-ray tube

Call your Westinghouse representative, or write:
Westinghouse Electric Corporation, Dept. E-6
2519 Wilkens Avenue, Baltimore 3, Maryland.

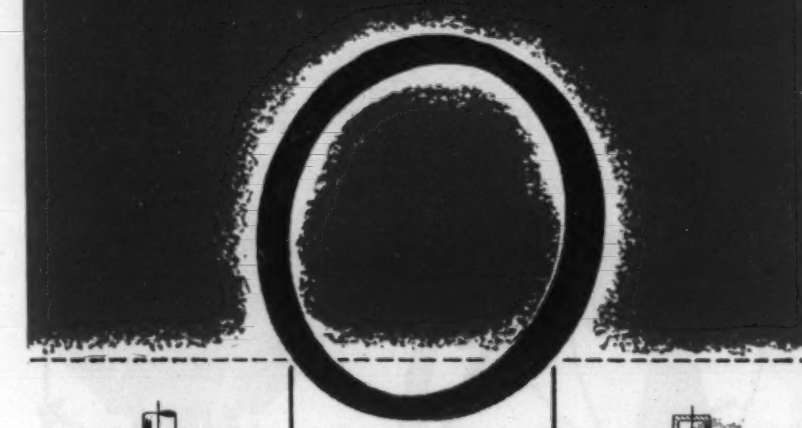
J-08260

YOU CAN BE SURE...IF IT'S

Westinghouse

INDUSTRIAL X-RAY

RETAIN PURITY
by installing
MORGANITE
SELF-LUBRICATING • NON-CONTAMINATING
PISTON RINGS



FOR OXYGEN COMPRESSORS AND OIL-FREE AIR COMPRESSORS

Morganite Advantages—Completely self lubricating, Morganite Piston Rings impart no taste or odor to contacting liquids or gases.

Operating Temperatures—Unaffected by heat or cold, maintain maximum efficiency over wide range. Eliminate "cold start" wear.

Suggested Applications — Recommended for compressors handling foods, chemicals, plastics, beverages, oxygen, or wherever purity is desirable.

Other Morganite Products — Include self lubricating seals, washers, valves, bearings, slides, vanes. Self-polishing feature eliminates costly finishes.

CONSULT OUR CATALOG in Sweet's File for Product Designers. Call or write for complete engineering data and recommendations on specific problems. Please supply drawings and specifications when requesting estimates.

see our CATALOG in SWEET'S FILE for PRODUCT DESIGNERS

REGISTERED TRADE MARK **Morganite** INCORPORATED

LONG ISLAND CITY 1, NEW YORK

Manufacturers of CARBON MOTOR and GENERATOR BRUSHES, CARBON PILES and SELF-LUBRICATING CARBON SPECIALTIES

List DN 81 on Reader-Service Card for more information

THIS RECORD SPEAKS FOR ITSELF

30 Years' Production of MOLDED PLASTICS for one of our customers!

Phenolic body parts by AUBURN

220 Different Parts

Ever since 1922 AUBURN has been producing molded plastics for the EASTMAN KODAK COMPANY. During this period 220 different custom molded parts have been delivered, each with a different engineering problem—each with a different solution—in compression molding, transfer molding, injection and extrusion.

In a field as highly competitive as molded plastics, performance such as this for one of America's foremost corporations speaks for itself. We feel that some of the reasons have included:

- **Versatility in producing parts that have met both volume and precision specifications in any plastic.**
- **Steady expansion of facilities and modernization of equipment.**
- **Research and organizational instruction to insure that standards of quality control are maintained.**
- **Consistent "on schedule" delivery.**
- **Ability to take the initiative in improving product design, reducing the cost to the customer.**

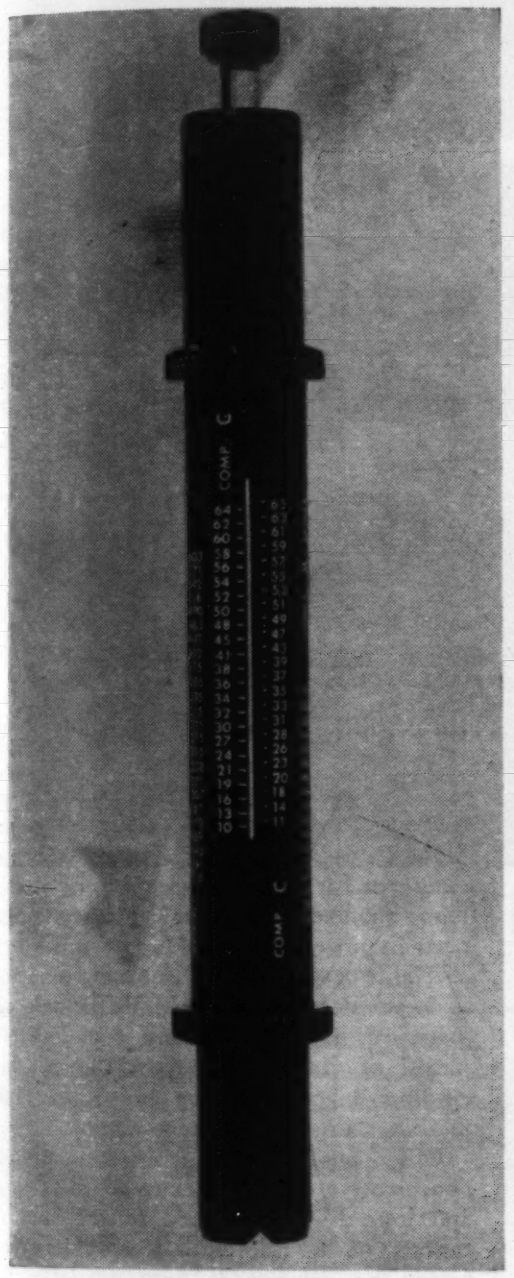
A dependable subcontractor, AUBURN molds any material by any modern molding method, including the new Vacuum Forming Process. Complete tool and die-making facilities are maintained. For the complete story of AUBURN, write for free booklet.

Auburn Button Works, Inc.

300 McMaster Street, Auburn, New York

Founded in 1876 Telephone 3-5320

New Materials and Equipment



Pocket-Size Metal Hardness Tester Affords Many Advantages

A pocket-size metal hardness tester weighing only 7 oz has been announced by *Peabody Industries, Inc.*, 1819 Broadway, New York 23. According to the company, the instrument has made possible testing of internal mold and die sections with an area as small as 1 sq in., where heretofore the throat and daylight openings of standard test machines limited testing to the periphery of the work.

For calibration and for use with parts weighing less than 15 lb, a clamping anvil is supplied in order to provide sufficient mass to obtain full rebound. On work weighing more than 15 lb, the mass is sufficient and the anvil is unnecessary.

Accuracy of the instrument is said to be identical with that of large equipment. On the new model, direct readings are obtained on any of three differ-

VELVAGLAZE

MONARCH VELVAGLAZED DIE CASTINGS USED ON THE GENERAL ELECTRIC CANNISTER CLEANER

Cuts Finishing Costs...

AND IMPROVES PRODUCT QUALITY

Velvaglaze is now used by leading manufacturers to obtain a more durable, brighter surface finish that improves product sales appeal. Velvaglaze resists scratching and marring experienced on normal cast aluminum surfaces.

Velvaglaze is available exclusively on Monarch aluminum Permanent Mold castings and aluminum Die Castings. Investigate the substantial savings you can obtain over other comparable fine finishing methods using Monarch Velvaglaze castings.

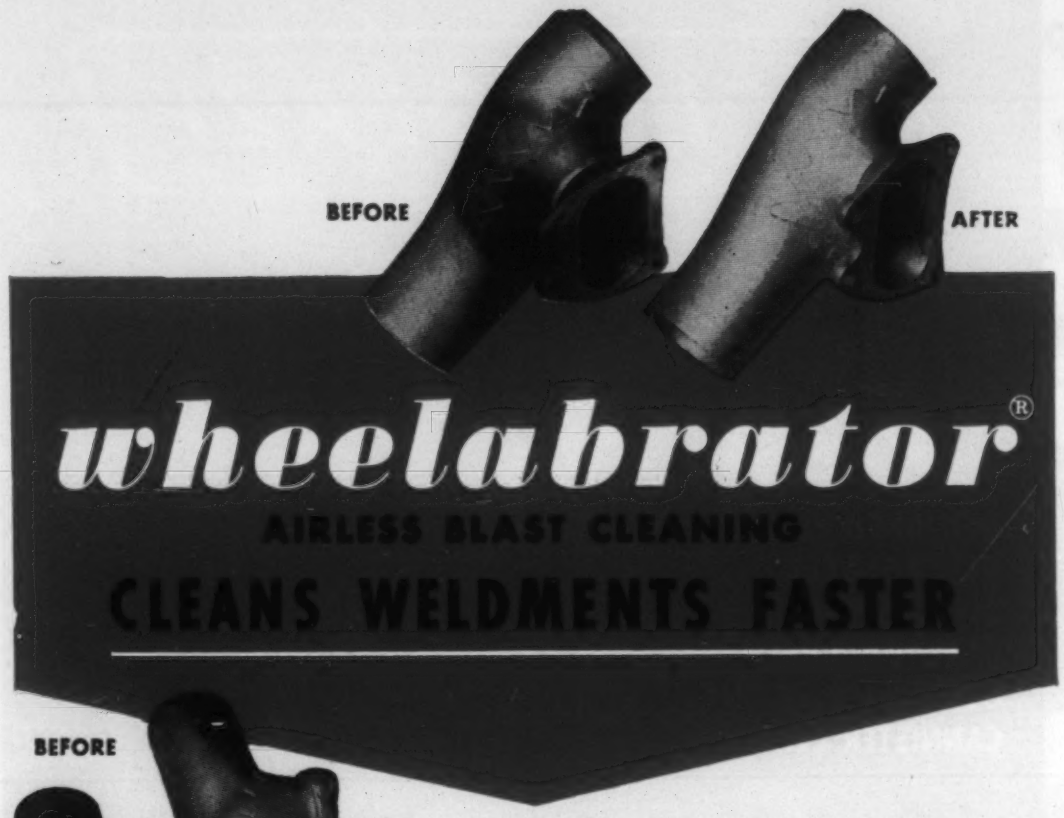
WRITE TODAY FOR FREE BROCHURE

"Here's How You Can Cut Die Casting Finishing Costs"

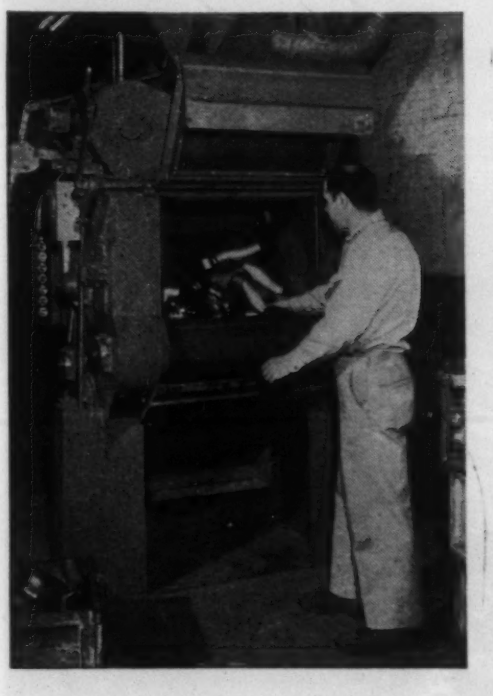
Monarch ALUMINUM MFG. COMPANY

- Aluminum Permanent Mold
- Aluminum Die Castings
- Certified Zinc Die Castings
- Complete Product Assembly
- Every Modern Finishing Service

Detroit Ave. at W. 93rd St., Cleveland 2, Ohio



Wheelabrator's fast thorough cleaning action scours metal surfaces brilliantly clean in but a few minutes — to save hours of cleaning time and cut costs to a minimum. That's the story at the B. H. Aircraft Company and everywhere else that Wheelabrator is used. Mr. Donald F. Baum, Vice-President, puts it this way:



Installation of the above Wheelabrator Tumblast saved 86% in cleaning time on pipe assemblies.

"We are currently using the Wheelabrator for cleaning of all details prior to the spot welding and/or silver brazing of these details on our pipe assemblies. These details are made from .032 low carbon and .065 nickel-chrommoly steel and range up to 4" x 4" in size. The average time for cleaning is about 14% of the time for sand blasting. Sub assembly bodies are now Wheelabrated in 70% of the time formerly required."

See for yourself how this high speed blast cleaning can help you reduce your costs and improve the appearance of your products. Ask for a test demonstration without obligation. *Write today for details.*

American
WHEELABRATOR & EQUIPMENT CORP.
538 S. Byrkit St., Mishawaka, Ind.

WORLD'S LARGEST BUILDERS OF AIRLESS BLAST EQUIPMENT

New Materials and Equipment

ent Rockwell and Brinell scales without the use of conversion charts.

Operation is claimed to be extremely simple: The operator merely extends the spindle to its full height, depresses the trigger, allows it to rebound where it stops and is held automatically, and reads the hardness directly from the calibrated scales on the tester. There are two models, one for steel and the other for use on nonferrous metal surfaces.

The instrument has been used successfully for testing materials such as fiberglass laminates, plastic sheet stock, wood, hard rubber, and others.

Detergent Cleans Aluminum and Magnesium

Kelite Products, Inc., 1250 N. Main St., Los Angeles 15, has announced a new detergent for the rapid cleaning of aluminum, anodized aluminum and magnesium parts in power washing equipment. Known as Kelite PWB No. 81, the new material is a powder which is readily soluble in water. It is said to afford complete removal of virtually all types of soil, including Reynolds, Alcoa and Kaiser ink markings in approximately 1 min.

Other qualities are, it is nonfoaming, noncorrosive and has extreme durability and long life. Developed to the specifications of a leading aircraft manufacturer, the product is now available to the national market.

Transparent Cement Provides Water-Tight Seals

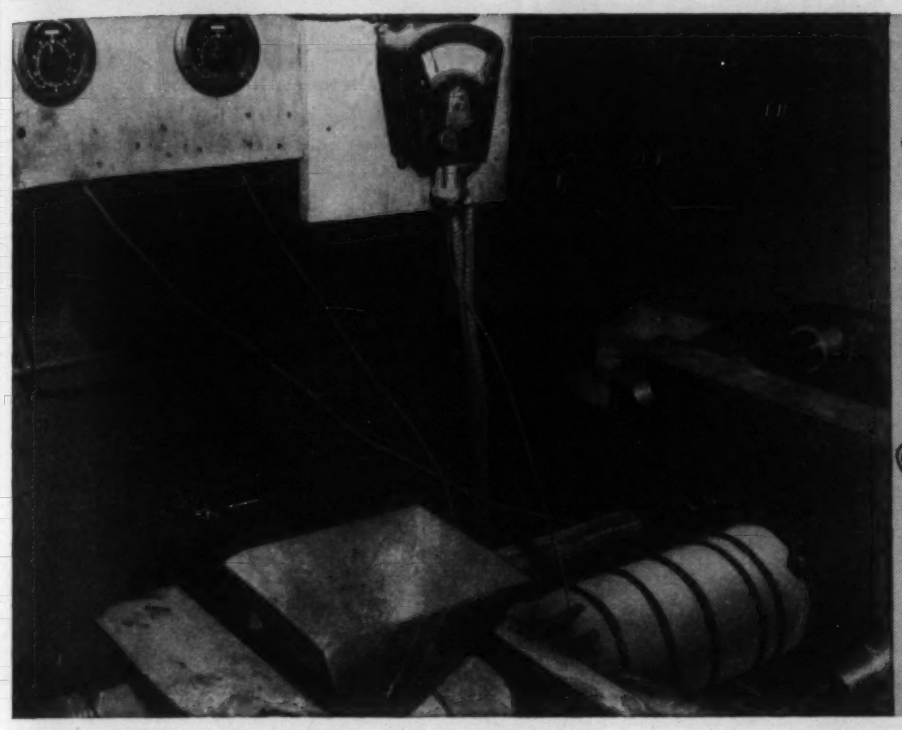
A new transparent cement specially developed for fast biting action on smooth and uneven surfaces of polystyrene plastic molded parts has been announced by *Adhesive Products Corp.*, 1660 Boone Ave., New York 60. The new adhesive, Sty-Fil Transparent Cement, is said to be excellent for sealing sections where seams must be water and air tight, as in the manufacture of such items as toy water pistols.

According to the company, the most valuable property of the cement is its unique ability to fill in irregularities and ruptured areas while sealing joints,

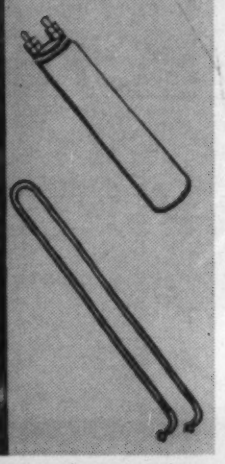
CHROMALOX

PROFITABLE IDEAS FOR BETTER PRODUCTION with ELECTRIC HEAT

Production TIPS



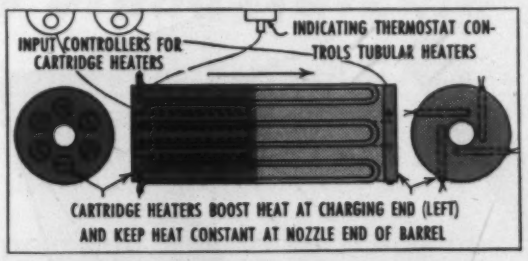
THESE CHROMALOX *Electric* HEATERS DID THE JOB

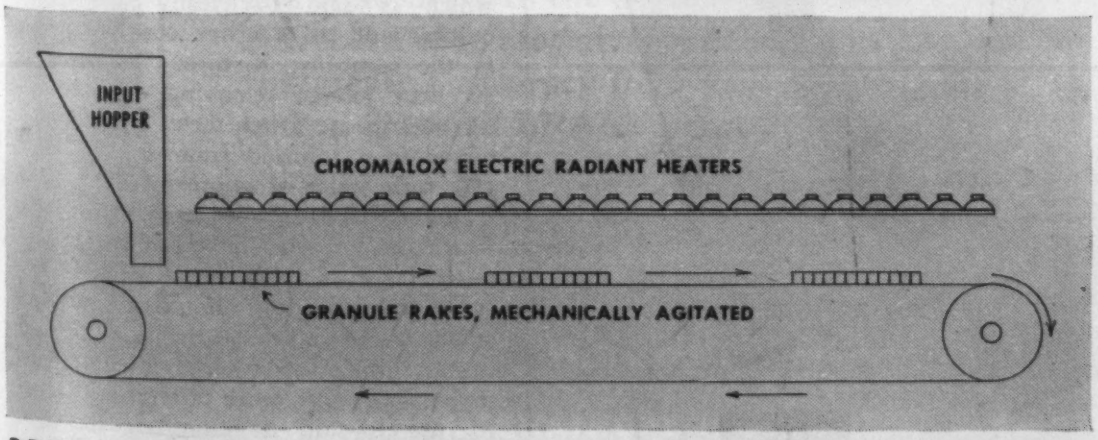


"ZONED" HEAT ANSWERS CRITICAL PROBLEM

Zones of heat, that are controlled easily and exactly to meet the molding characteristics of nylon just "come naturally" when Chromalox Electric Heaters are the heat source. Six thermostatically controlled Chromalox Tubular Heaters, clamped around the barrel, uniformly heat its entire length. Six Chromalox Cartridge Heaters inserted at the feed end act as booster heaters to liquefy the charge. Four Cartridge Heaters keep temperatures at the required levels in the nozzle. Each set of cartridge heaters is controlled by a Chromalox Input Controller; while an indicating thermostat controls the tubular heaters. Heat is regulated to the exact temperatures required for every mold size. Optimum operating heats are easily redialed when needed.

Diagram below illustrates the 3 heat zones, each controlled individually.


INPUT CONTROLLERS FOR CARTRIDGE HEATERS
INDICATING THERMOSTAT CONTROLS TUBULAR HEATERS
CARTRIDGE HEATERS BOOST HEAT AT CHARGING END (LEFT) AND KEEP HEAT CONSTANT AT NOZZLE END OF BARREL

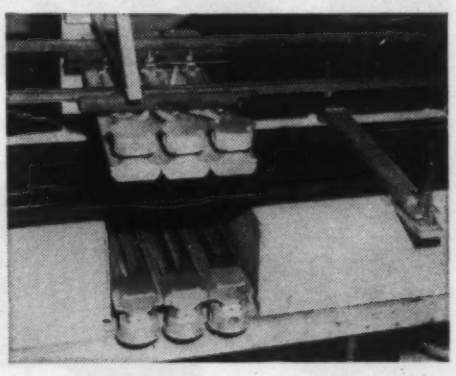


DRYING PLASTIC GRANULES SPEEDILY AND UNIFORMLY

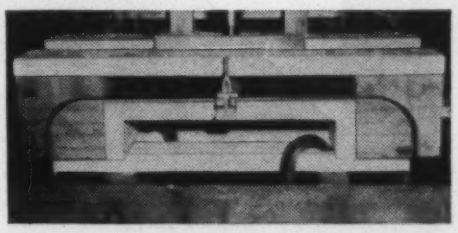
One plant's solution for drying granules was this conveyorized set-up which dries the granules enroute from hopper to barrel. Chromalox Radiant Heaters are "color-blind;" their *far*-infrared energy is absorbed almost equally fast by all colors. Radiation is uniform; output is regulated easily to avoid overheating and sticking.

HOW PLASTIC RODS ARE BENT QUICKLY, EASILY, ECONOMICALLY

A table was built (photo A), with Chromalox Electric Radiant Heaters positioned above and below the portions of the rods to be heated. A forming press (photo B) was built to form the rods. About 30 rods, clamped together for efficient handling, are heated and formed at one time.



A—Concentrated *far*-infrared heat is absorbed efficiently and rapidly by plastic rods of all colors.



B—Forming jig bends heated rods quickly, was made in company's own shop.

CLIP and MAIL COUPON

Industrial Division
EDWIN L. WIEGAND COMPANY IC-67
7523 Thomas Blvd., Pittsburgh 8, Pa.

My heating problem is_____

_____

_____

☐ Have your Application Engineer get in touch with me.
☐ Send me a complete Chromalox Catalog.
☐ Put me on your mailing list for helpful Chromalox literature.

Name_____

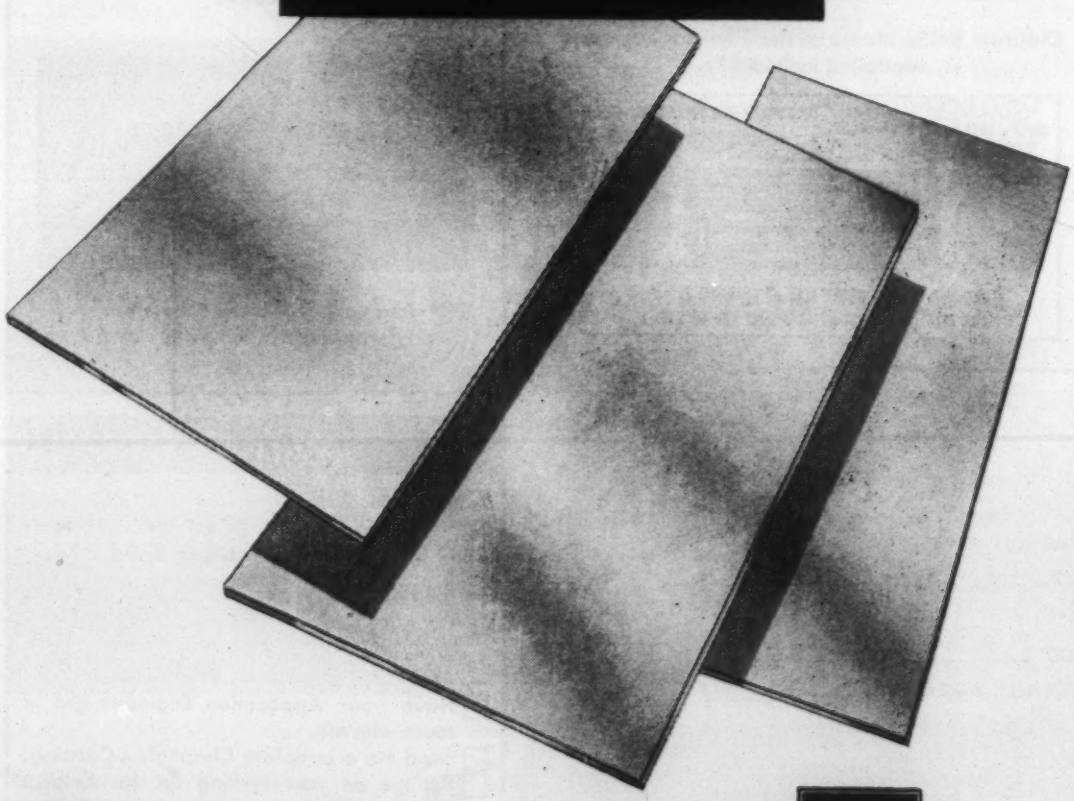
Company_____

Street_____

City_____ Zone____ State_____

Ingersoll
specializes in . . .

Heat-Resisting
STEELS



Ingersoll STEEL DIVISION
BORG-WARNER CORPORATION
310 South Michigan Avenue, Chicago 4, Illinois
Plant: New Castle, Indiana

ENGINEERING B-W PRODUCTION

New Materials and Equipment

and its equally powerful bonding properties on both even and uneven surfaces.

It is expected that the widest use of the new adhesive will be made in toy manufacturing, where the wide use of polystyrene molded parts has resulted in an urgent need for a fast-biting, easily applied, waterproof cement.

Graphitic Steel Now Available in Hollow Bars

Graph-Mo Hollow-Bar, a new graphitic steel product, has been announced by the Steel and Tube Div., *Timken Roller Bearing Co.*, Canton 6, Ohio. The new product is a turned and bored bar section which uses for the basic material the familiar Graph-Mo tool steel.

According to the company, the new product will have all the advantages of graphitic-type tool steel plus the convenience of the hollow bar section in manufacturing ring gages, dies and other annular tool steel parts. The material will be stocked in 15 cities in size ranges from about 3 to 16 in. o.d. with a variety of wall thicknesses.

Improved Chemical Solvent for Metal Cleaning

Wayne Chemical Products Co., Copeland & MCRR, Detroit 17, has announced a new and improved chemical solvent which is said to clean parts better, quicker and at a lower cost. According to the company, Kemisol "A" does an excellent job of removing all traces of oil and grease from metal parts. When mixed in a solution from ½ of 1% to 1% with water at approximately 180 F, it offers a thin, inexpensive solution which can be used in almost all methods utilized for cleaning metal parts.

Neutral, odorless, nontoxic, nonflammable and harmless to the skin, the solvent is noncorrosive to aluminum, brass, copper and most other nonferrous metals. Its use is said to eliminate the need for chlorinated or inflammable solvents now being used in the cleaning of aluminum.

Finding wide application, the new product is currently being used in the manufacture of ball and roller bearings

an **ACCO** product

Sphero-Conical DIAMOND **BRALE*** PENETRATOR for Hardened Steel

HOW IT WORKS

A. Minor Load Penetration

B. Major Load Penetration

C. Linear measurement of penetration increase which "ROCKWELL*" converts to hardness reading

BRALE Penetrator Accuracy Is Proved in Wilson's Standardizing Laboratory

● One point of hardness on the Rockwell C scale equals .00008" so penetrator accuracy must be constant. That's why Wilson maintains its Standardizing Laboratory for testing on many test blocks and approving every BRALE penetrator.

Each BRALE is precision ground to shape under high magnification and is accurate to the degree required for a research laboratory. Wilson's BRALE Penetrator gives true readings at all points on the dial. To get the greatest accuracy from your hardness tester, see that it is equipped with a diamond BRALE penetrator.

*Trade Mark Registered

ACCO

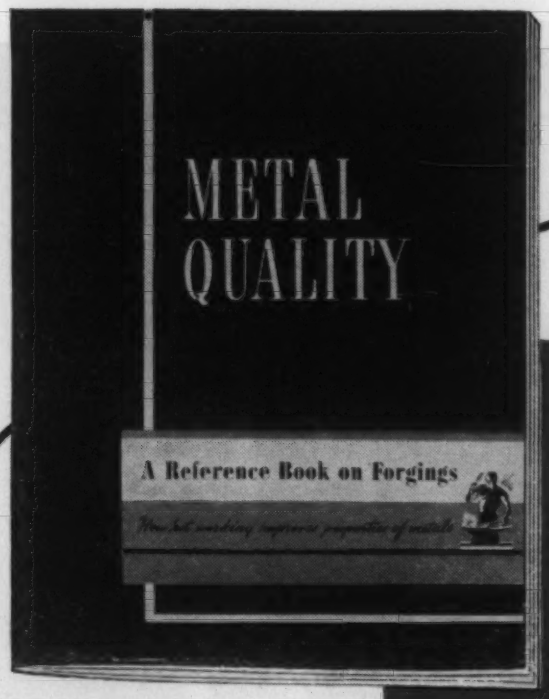
TRADE MARK

Write for literature

WILSON MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE

230-E Park Avenue, New York 17, N. Y.

WILSON "ROCKWELL" and TUKON Hardness Testers



Engineering, production and economic advantages obtainable with forgings are presented in this Reference Book on forgings. Write for a copy.

FORGINGS ARE UNUSUALLY EFFECTIVE FOR SOLVING PROBLEM PART PROBLEMS

A problem part problem, however complex, often ceases to be a problem once all the aspects of the part are checked with the unrivaled economic and mechanical advantages of closed die forgings and the closed die forging process for producing parts. Whatever the nature of problems that make a problem part, consult a forging engineer to determine the extent to which forgings can help you solve them.

DROP FORGING ASSOCIATION
605 HANNA BLDG. • CLEVELAND 15, OHIO

Please send 60-page booklet entitled "Metal Quality—How Hot Working Improves Properties of Metal", 1949 Edition.

Name .....

Position .....

Company .....

Address .....

New Materials and Equipment

and other parts prior to heat treatment, stainless steel cooking utensils, and for cleaning auto parts before chromium plating or lacquering. It is also being used for cleaning machined aluminum aircraft parts.

Cemented Chromium Carbide Sample Available in Many Shapes and Sizes

A sample test kit containing a variety of shapes and sizes of the new Grade 608 cemented chromium carbide is now available from *Carboloy Dept., General Electric Co.,* 11177 E. 8 Mile Rd., Detroit 32. The kit has been assembled to enable product designers, development engineers, process engineers and metallurgists to make a wide variety of metallurgical, physical and chemical tests to check the corrosion, abrasion and erosion resistance of the new carbide in specific applications.

Grade 608 chromium carbide, a strong and stable nonmagnetic metal that contains 83 chromium carbide, 2 tungsten carbide and 15% nickel, has about the same density as SAE steel and approximately the same thermal coefficient of expansion as steel. It has shown remarkably high resistance to acids, salt spray, steam erosion, and high temperature oxidation—combined with good abrasion resistance. Series 600 chromium carbides are as machinable and as hard as tungsten carbide. Fabrication and finishing techniques for these metals are said to be identical to those for tungsten carbide.

Typical applications indicated for

When Shortages Bedevil You Think of OILITE

OILITE Finished Machine PARTS Assure YOU

- ★ No Tooling on Your Part.
- ★ Fast Delivery (Normally two (2) to six (6) weeks).
- ★ Accurate Parts (Machine Tool Tolerances).
- ★ Low Cost (Less than Machined Parts).
- ★ An Engineered Product.
- ★ Greater Freedom in Design.
- ★ Broad Range as to Size and Materials.
- ★ Consultation with Field Engineers.
- ★ The Benefit of More than Twenty (20) Years of Powder Metallurgy "KNOW-HOW."

We are told—"OILITE is the Favorite"

AMPLEX • MANUFACTURING COMPANY

Subsidiary of Chrysler Corporation

Detroit 31, Michigan

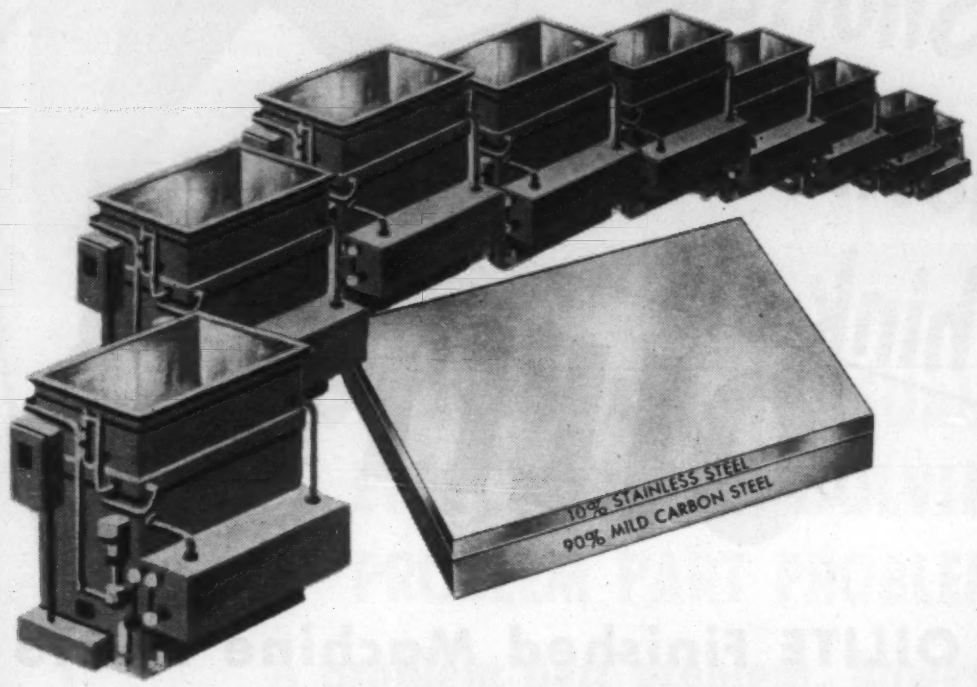
FIELD ENGINEERS AND DEPOTS THROUGHOUT UNITED STATES AND CANADA

Oilite Products Include: Bearings, Finished Machine Parts, Cored and Solid Bars, Permanent Filters and Special Units.

Copyright 1952—The Chrysler Corp.

How to Make Stainless Protection Go NINE TIMES FURTHER... with PERMACLAD

STAINLESS CLAD STEEL



Want stainless protection for your product or equipment—without wasting stainless steel? You'll get it at low cost—with PERMACLAD!

A 10% layer of stainless, inseparably welded to a 90% mild steel backing, gives PERMACLAD the surface characteristics of solid stainless *and* the easy forming qualities of carbon steel. This means real savings in corrosion resistance and in fabrication as well. For you can cold-form PERMACLAD with ease, draw it deeper without intermediate annealing, actually form it into products impossible with many other materials.

Even with the most severe draw, the percentage of cladding (which can be 20% or more if desired) never varies. And the stainless layer remains inseparably welded to its backing. For gleaming, stainless products and corrosion resistant equipment, design and build with PERMACLAD. The coupon below brings you full details in our new 8-page folder (P-97).

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Other Products: A.W. ALGRIP ABRASIVE Floor Plate • A.W. SUPER-DIAMOND Floor Plate • Plates • Sheets • Strip • (Alloy and Special Grades)

New Materials and Equipment

Grade 608 carbides include: shear blades for molten glass; core pins for baking ceramic parts; finishing rod guides; centrifuge nozzles in separating equipment; bearings where corrosives are present; textile guides; nozzles and valves for processing soaps, fats, oils, foods, chemicals, petroleum products, pharmaceuticals and fruit juices; valve and core pins in die casting processes; punches for movie film; and many other applications where stainless steel is not sufficiently abrasion resistant.

The kit contains:

(3) ¼-in. sq bars 2 in. long
(2) ¼-in. sq bars 1 in. long
(3) ½-in. o.d. 5/16-in. long bushings with a 5/16-in. i.d.
(1) ⅛-in. dia rod 1 in. long

Pre-Cleaner for Drawing and Extruding Steel

A compound designed especially for use as a pre-cleaner for steel that is to be deep drawn or extruded has been announced by the *Detrex Corp.*, Detroit 32. Detrex 61 is used in a soak tank at approximately 190 F at a concentration of from 6 to 10 oz. per gal. It is said to completely remove dirt from all ferrous parts.

In addition to possessing high wetting and penetrating properties, the compound is very free rinsing. It does not contain fatty acids or resin soaps.

Welding Development Eliminates Porosity in Inert-Arc Welding

Spekaluminite Co., 100 S. Water St., Ossining, N. Y., has announced the development of a new fusing agent and deporosite, Weldaluminite, which is said to extend the application of inert-arc welding to rimmed steel producing welds free from porosity. Containing aluminum which deoxidizes the weld pool, the new material is so formulated that it retains the aluminum at the point of welding. No gas bubbles rise to the surface of the pool to cause tur-

DETREX DEGREASERS

BETTER CORROSION PROTECTION

LOWER HEIGHT

NEW TEFLON SEAL IN SOLVENT PUMP

SMOOTH INTERIOR SIDE-WALL

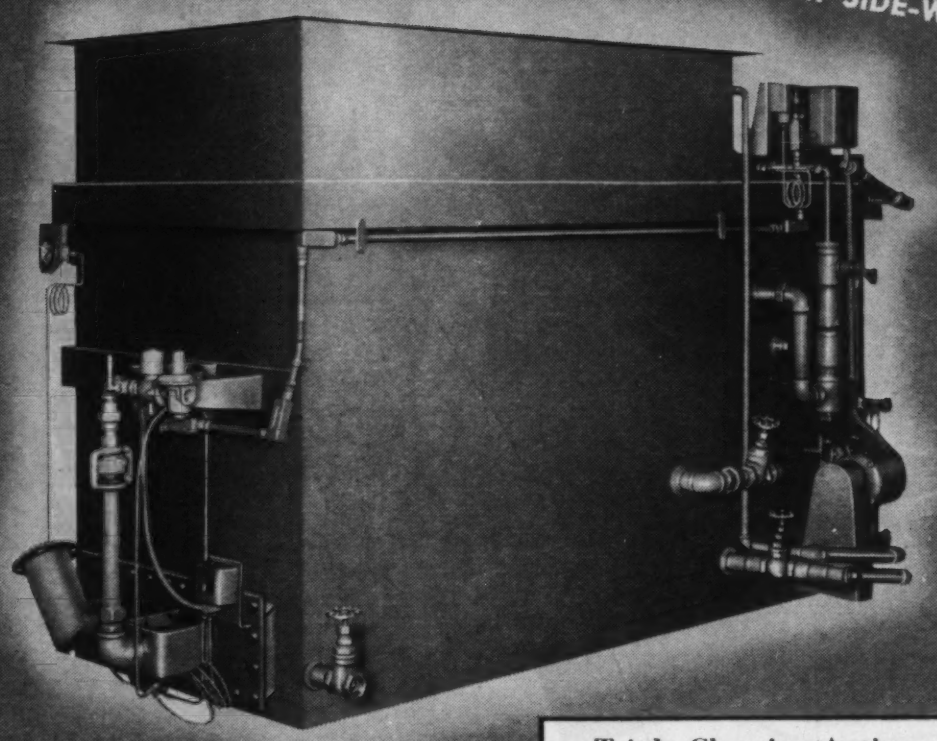
MOST EFFICIENT GAS BURNER

ENLARGED ACCESS DOORS

LESS FLOOR SPACE

OPERATED FROM EITHER SIDE

INTEGRAL STORAGE TANK COMPLETELY ACCESSIBLE



Triple Cleaning Action:
(1) initial pure vapor cleaning; (2) spray flushing with oil-free solvent distillate; (3) final pure vapor rinse.

9 great new features ... in the VS 800 series

Industry's most popular type of hand-operated degreasers—the Detrex VS 800 Series—have been redesigned with 9 important advancements to afford still more economy of operation, greater utility and easier maintenance.

New atmospheric gas-fired immersion tube heating elements increase heating efficiency 50% (in some cases as much as 100%), save fuel, and permit thermostatic control of the heating tube. (VS 800 degreasers also are quickly adaptable for electric or steam heating.)

The interior of the degreaser, including the distillate reservoir, is coated with FF-1 . . . the new Detrex non-porous coating which is completely moisture-resistant and unaffected by degreasing solvents. It has shown no failures after severe and prolonged field use.

Redesign of the Detrex VS 800 has removed all interior projections, lowered working height, and provided flexibility of operation from either side. Compact construction has reduced floor space, the storage tank has been built into the unit to eliminate a separate container, and maintenance has been made easier by the enlarged access door. A new pump design uses corrosion-resistant materials throughout, and features a new teflon mechanical seal to eliminate solvent leaks.

These are but a few of the reasons why VS 800 degreasers lead the field. Get all the eye-opening facts about the improved features, wide range of sizes, and many uses of these redesigned degreasers, as well as other Detrex standard and special models. Call your local Detrex field office or write direct to DETREX CORPORATION, Box 501, Detroit 32, Michigan. D-1

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PHOSPHATE COATING PROCESSES

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To assist you in your re-tooling problems . . . or to help you analyze your present welding methods so that you may enjoy maximum speed, efficiency, and economy in many of YOUR production problems . . .

Giant new 4th Edition contains 62 new photographs, 132 new drawings, 72 pages of helpful data covering basic and advanced welding techniques and designs used in fabricating and assembly. Profusely illustrated with application drawings; weld diagrams; tables of melting temperatures, strengths, corrosion factors; charts; alloy recommendations; etc. Convenient digest size.

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*City*_____ *State*_____

New Materials and Equipme

bulence. As a result, porosity is said to be eliminated and the arc is stabilized.

Weldaluminite is either sprayed or brushed on the joint to be welded and allowed to dry before welding is begun. No expensive filler metal need be used in many welding operations.

Further research is progressing on the application of the material in the welding of ferrous and nonferrous metals to improve welding technique.

Powder for High Temperature Brazing Molybdenum and Tungsten

American Electro Metal Corp., 320 Yonkers Ave., Yonkers 2, N. Y., has announced the development of a new material for the very high temperature brazing of molybdenum and tungsten electronic components. According to the company, the material is a powder, Mo-braze, which melts at a temperature of approximately 3450 F and forms a continuous and very strong braze upon solidifying.

The brazed joint is formed very rapidly, usually without any oxidation of the parts. In the furnace brazing of large parts, excellent brazed assemblies are said to be obtained in the range between 3450 and 3800 F. Mo-braze can be used satisfactorily to braze molybdenum to molybdenum, tungsten to tungsten, and molybdenum to tungsten. This braze will not volatilize to any detectable extent at useful temperatures, whether in hydrogen or extreme vacuum. Tests for 1000 hr and longer in 10—6 mm of mercury vacuum have not produced any poisoning of the vacuum.

Optical Level Measures Flatness, Straightness and Parallelism

A newly developed optical level for measuring flatness, straightness and parallelism and which reads deviations from the horizontal of 0.00012 in. per ft of length or 0.0001 in. per inch of length, is offered by *F. T. Griswold Manufacturing Co.*, W. Lancaster Ave., Wayne, Pa. This inherent accuracy is

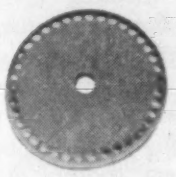
Tool Steel Topics

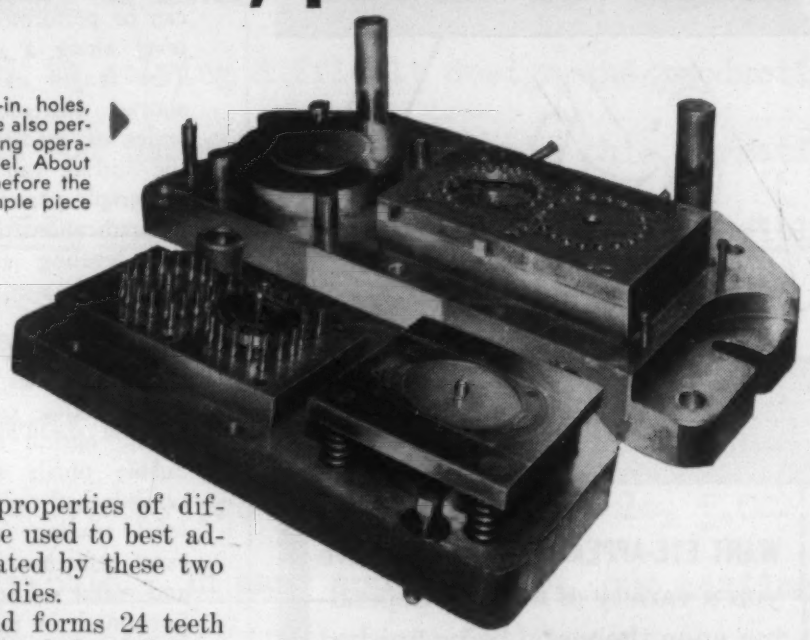
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

The Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BTR and LEHIGH H team up to form 24 teeth, punch 39 holes

In addition to punching 39 ¼-in. holes, this four-station progressive die also performs a blanking and embossing operation on 11-gage hot-rolled steel. About 25,000 pieces are produced before the die requires redressing. A sample piece is shown below.





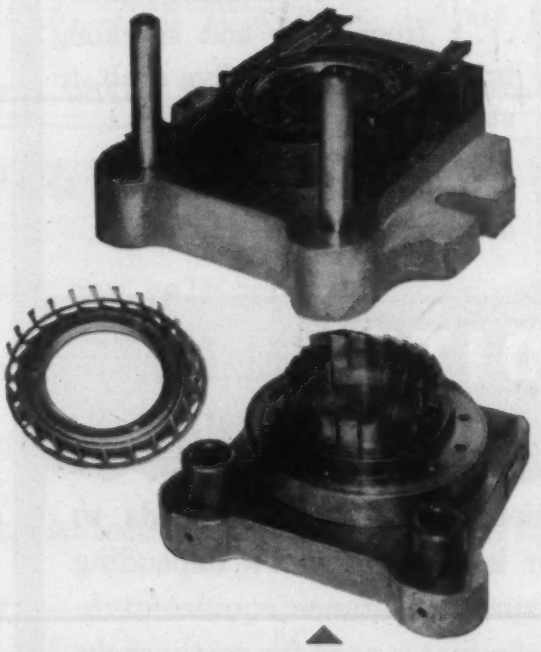
How the outstanding properties of different tool steels can be used to best advantage is well illustrated by these two punching and forming dies.

One die punches and forms 24 teeth and punches three ¼-in. holes, all in a single operation. The other die punches 39 holes of ¼-in. size, blanks out the piece, and embosses it.

The punches of both dies are made of BTR, our manganese-chromium-tungsten oil-hardening steel with a hundred and one uses. It has plenty of wear-resistance, and it takes the shock of the punching operation. BTR is easy to machine and heat-treat. And it's economical.

The die rings for both dies are made of Lehigh H, our general-purpose grade of high-carbon, high-chromium steel. This air-hardening grade is first choice wherever it's essential to have minimum distortion during heat-treatment. In addition, Lehigh H provides long-wearing properties for those long runs. You just can't get a better tool steel when you need accuracy and long wear.

Both these Bethlehem grades are stocked in popular sizes by Bethlehem tool steel distributors in principal cities everywhere, and in our mill depot.



This die punches and forms 24 teeth in 18-gage cold-rolled steel and punches three ¼-in. holes. About 50,000 pieces are produced before redressing.

METALLURGICAL SERVICE — Bethlehem metallurgists are on call whenever you have problems. They'll assist with the selection of tool steel, or its heat-treatment, forging, grinding, machining, design, etc.

Sometimes it takes more than just good tool steel

In a customer's plant the other day we asked the shop boss the name of the tool steel he used for a blanking die which we saw in his shop.

"Sorry, but I just can't tell you. All I know is, it works fine. We used to have a lot of trouble with that die . . . and then one of your Bethlehem men came in here one day. He worked with the die all day, and he cured the trouble for good."

Later we checked with the toolroom and found that the grade used for the die was BTR, our general-purpose, oil-hardening tool steel — and a mighty reliable one, too. The fact that the superintendent didn't know its name was probably a compliment. It was doing a good job. He no longer had to worry about it. So the name didn't matter.

The point is, it takes more than the best tool steel to make some tools and dies work right. Sometimes what counts most is the service that goes with the tool steel — our vast experience in applying each grade, the sales service, metallurgical service, and distributor service.

"Service" is often a glib promise, an intangible sales point. But we at Bethlehem look on service as an inseparable part of our product, something that goes along with every bar of steel we ship.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Special treatment often permits using carbon tool steel

We have run across several customers who use carbon tool steels for tools and dies that others would ordinarily make from oil- or air-hardening tool steels. This is real economy.

The secret in most cases is in the design of the tool. Avoided are: sharp corners, small projections from heavy sections, numerous holes with both thick and thin webs. If the tool can be designed to minimize such hazards, carbon tool steel is often an effective solution.

When there are many holes in a die made from carbon tool steel, a good heat-treater will carefully pack the holes with asbestos or fire clay, then heat carefully and uniformly to obtain a well-hardened die. This precaution reduces distortion during heat-treatment and avoids causing cracks in quenching.

HEAT AND TEMPER COLORS SHOWN ON HANDY CHART

Want to estimate the temperatures of heated steel? Our convenient color chart is printed in natural tones; heat colors are accurately reproduced on one side and temper colors on the other. Write for your free copy to Publications Dept., Room 1042, Bethlehem, Pa.

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Simple chemical dip; immersion time only 10 seconds to 2 minutes; no sealing dip; color is clear or yellow depending upon your requirements; salt spray resistance equivalent to 20 to 30 minutes of anodizing, eliminates need for costly racks and electrical power.

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for Corrosion Protection and Paint Systems on Non-Ferrous Metals; ANF Plating Brighteners

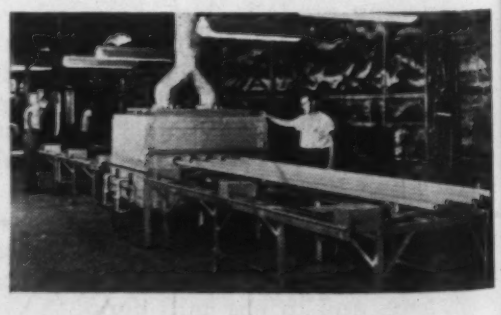
New Materials and Equipment

said to make possible the checking of flatness of surface plates and machine tool beds, the straightness of cylindrical rolls, and the parallelism of V-ways or flats to values well within the closest working tolerances.

According to the company, the most critical leveling and measuring operation can be performed. Simply by moving the level along a surface 7 in. at a time (the length of the instrument) or in shorter increments and by taking a series of readings, the entire length of the surface can be checked and plotted on graph paper.

Applications include dozens of everyday leveling and checking operations, such as inspecting flatness conditions of machine beds, surface plates, ground shafts, paper and dryer rolls, jigs, fixtures, airframes, lofting, lapping plates, and checking spindle arbor runout.

The optical system consists of three bubble phials and two prisms so arranged that twice the usual accuracy of level reading is obtained and a very exact reference is observed. The amount and value of deviation from the true horizontal in the work piece being examined are measured by means of a large diameter, graduated micrometer thimble and barrel with easily read figures and markings.



Porcelain Enamel Furnace Fuses Inside and Outside Pipe Surfaces in Same Operation

A continuous porcelain enamel fusing furnace has been developed by *Barrows Porcelain Enamel Co.*, Cincinnati, for use in its plant operations. Designed and built by the company to fuse both the inside and outside of different sizes of pipe at the same time, the furnace is said to have solved several handling problems and improved quality. Its

ALLOY PRECISION Castings Company

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Important pass this on

To Executives Charged with Responsibilities
of Design, Development and Production:

This is intended to call your attention to the Mercast frozen mercury process of investment casting — a development that manufacturers find helpful in solving difficult design and production problems. We suggest that you immediately investigate this versatile process which makes available one-piece shapes previously impossible to cast or machine.

Get this!

Frozen mercury patterns and our special ceramic investment material permit surface finishes and dimensional tolerances never before available in foundry production. For example, ±.002 to .003" per inch is consistently held. In many applications, our castings require no finish machining. Some mercastings, with intricate shapes and cavities, were previously fabricated parts which required expensive machining and assembly, or were too costly to make at all.

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Our metallurgists can help you get mass production in such hard-to-machine metals as pure nickel, Hastalloy B, Rexalloy 108, stainless, Stellite, and others, both ferrous and nonferrous, at exceptionally close tolerances. Current applications — radar, aircraft, automotive, electrical, and machinery — indicate the wide, economical adaptability of mercasting. Here may be the answer to your problems involving design ... materials ... costs ... weight ... time ... machining capacity.

this hits home

If this discussion suggests use of mercastings by your company, write to Dept. A-3 for Bulletin 706 — or tell us your specific problems. Our metallurgists and Mercast engineers will be glad to serve you.

Sincerely,

Alloy Precision Castings Company

Alloy Precision Castings Company

Drop a note today! Let us help you with those tough problems...

We may KNOCK YOUR HAT OFF

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If you're a Big User of Tiny Parts Such as These!

Sound like exaggeration? Not when you know that the electronic tube industry looks to The Bead Chain Mfg. Co. for its millions of radio tube pins. Or, that builders of electrical apparatus turn to us for the contact pins, terminals, jacks and sleeves required in tremendous quantities.

For pin-like parts, and variations of bushings needed for *mechanical* purposes, as well, we are the money-saving supplier to scores of famous makers of products like toys, business machines, appliances, ventilators.

You save . . . if we can make it! We can almost say with certainty that if we can make that part (*up to ¼" dia. and to 1½" length*) you use in large quantities, we can show you a big saving. And, assure on-time deliveries to meet your defense work schedules! We have something unique back of that claim . . .

Nobody has What We Have! To be able to produce our famous Bead Chain to sell for pennies per yard, we had to develop *our own* equipment and method . . . our Multi-Swage Method.

Instead of turning and drilling parts from solid rod, or stamping and forming them, our Multi-Swage Method automatically swages them from flat stock into precision tubular forms, with tight seams. By increasing the production rate many times and eliminating scrap, this saves a large part of the cost by other methods.

What We Can Make. Parts may be beaded, grooved, shouldered, and of most any metal. Generally, should not exceed ¼" dia. or 1½" length. Catalog shows many *Standard Items* available in small quantity. *Special Designs* must usually be ordered in lots of a half-million or more, unless they are frequently reordered.

Get Cost Comparison. Send blueprint or sample and quantity requirements. We will return an eye-opener on economy.

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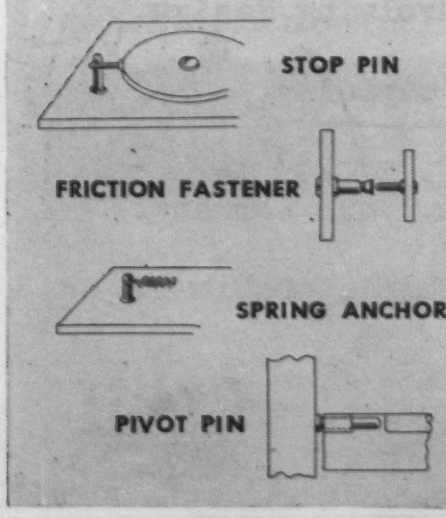
Shaft bearings—Foot or rest pins—Spacers between parts—Shoulder pins for permanent attachments.



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MULTI-SWAGE METHOD

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Company.....

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New Materials and Equipment

prime advantage is that it eliminates handling marks on the pipe.

The pipes are first coated with liquid porcelain enamel, or slip-dried, then placed on rollers adjacent to the furnace, and are advanced and rotated at a uniform rate. Rollers are set at an angle to the direction of travel. The slow, continuous movement of the pipe gives the enamel enough time to fuse to the pipe for a uniform coating.

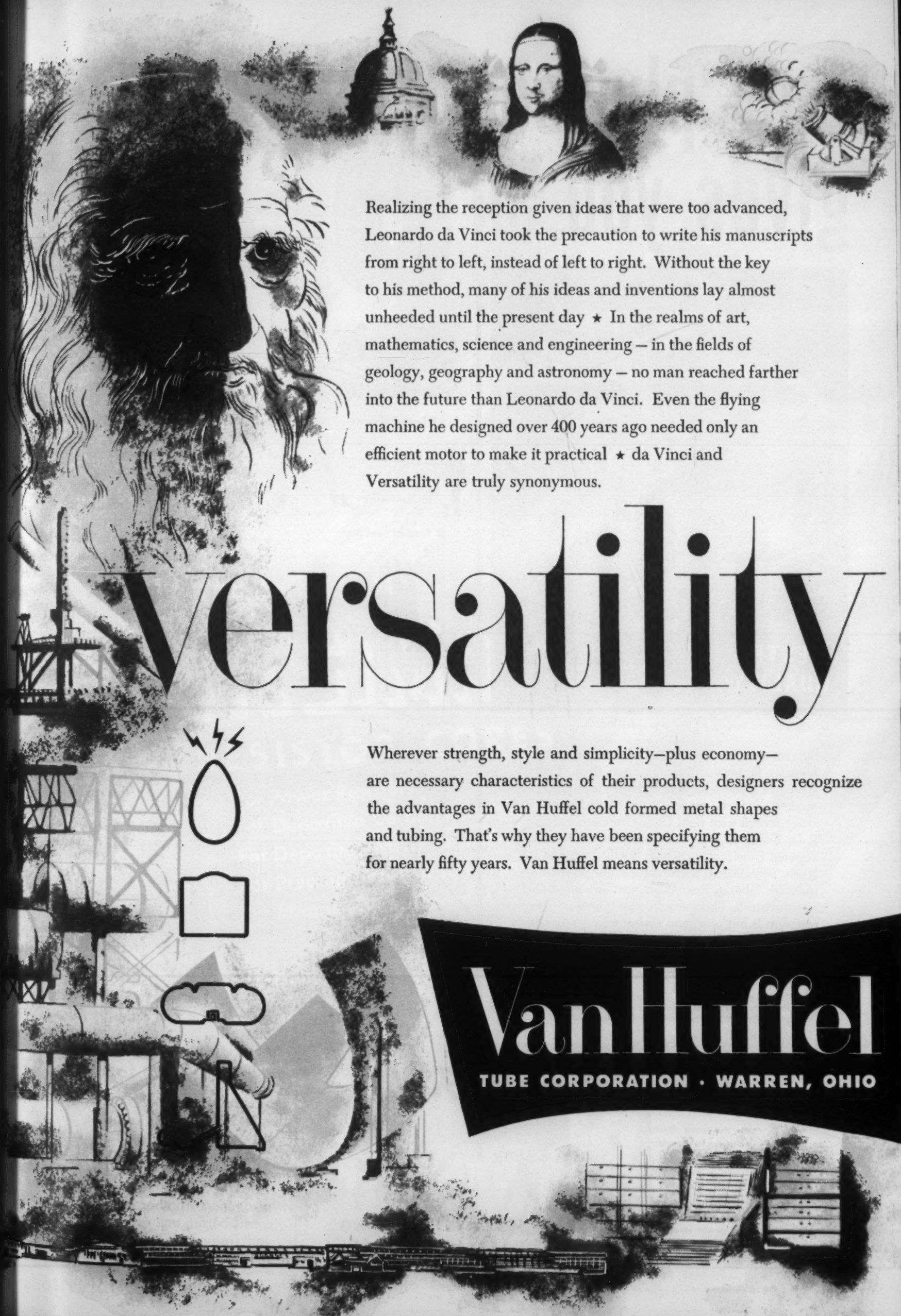
Five different standard 21-ft lengths of pipe, up to 2½-in. o.d. dia can be run through the gas fired furnace at the same time. The furnace, with handling rolls, is 30 ft long. Production is 1800 lineal ft of pipe per shift.

Compression Press for Plastics Molding

A new Model 726 press for compression molding is currently available in either 100- or 200-ton size from *F. J. Stokes Machine Co.*, 5500 Tabor Rd., Philadelphia 20. The new press is useful as a one-press installation or as an addition to established plastics molding equipment. It is adapted for a wide range of molding, including deep draw work on large parts. Complete radio cabinets, deep bowls, frameworks and bases, lamp reflectors and other sizable pieces are said to be well within the scope of the new press.

All steps in the molding cycle are controlled by the exclusive Stokes bar controller, which provides automatic cycle control through simple movement of buttons on graduated bars. A new type of three-speed controlled closing reduces closing time of the press and eliminates potential mold damage. The initial ram approach is at high speed, with a slower intermediate approach and final closing only as fast as the material plasticizes. Molded parts are of high density and uniformity, and pieces with projections and small pins are easily produced. A double-acting ram eliminates external pull-back cylinders.

Unusual features claimed for the new press are: the main cylinder and bed of the press are cast in a single piece so that no gaskets are required; the chamber is fully leakproof; the base is of welded steel and carries web channels running the full length so that the press is easily anchored to any solid foundation.



Realizing the reception given ideas that were too advanced, Leonardo da Vinci took the precaution to write his manuscripts from right to left, instead of left to right. Without the key to his method, many of his ideas and inventions lay almost unheeded until the present day ★ In the realms of art, mathematics, science and engineering – in the fields of geology, geography and astronomy – no man reached farther into the future than Leonardo da Vinci. Even the flying machine he designed over 400 years ago needed only an efficient motor to make it practical ★ da Vinci and Versatility are truly synonymous.

versatility

Wherever strength, style and simplicity–plus economy–are necessary characteristics of their products, designers recognize the advantages in Van Huffel cold formed metal shapes and tubing. That's why they have been specifying them for nearly fifty years. Van Huffel means versatility.

Van Huffel

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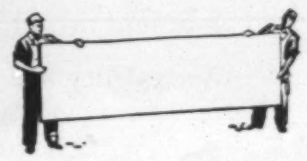
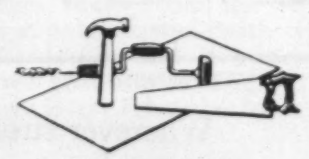
U. S. Commercial Standard CS45-48 details performance requirements, gives types, grades, sizes. For free copy, write Douglas Fir Plywood Association, Dept. 469, Tacoma, Wash.

1 Tested Quality

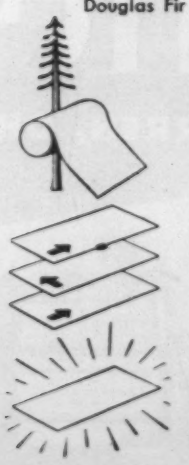

2 Large Panel Size

3 Cross Laminated Strength


4 Workability

5 Attractive Appearance

6 Light Weight


Douglas fir plywood is real wood, made by "unwinding" giant logs
into thin wood sheets which are inseparably cross-laminated
to form large, light panels having beauty and great strength

Douglas Fir Plywood

AMERICA'S BUSIEST BUILDING AND INDUSTRIAL MATERIAL

News Digest

continued from page 13

rials from silicizing tungsten and molybdenum. By silicizing, molybdenum can be protected against oxidation up to 3200 F, and tungsten up to 3600 F. According to the speaker, sintered silicides appear promising not only as heating elements but also for gas turbine and rocket applications. During the discussion of this paper, Dr. R. Kieffer reported on new heating elements which have recently been developed in the research laboratories of the Metallwerk Plansee. Two types of elements were shown in operation, the first silicized molybdenum, and the second sintered molybdenum silicides. The latter type will permit furnace temperatures of 3100 F. Since the material is claimed to have the required mechanical strength and thermal-shock resistance, the new development is expected to have a far-reaching effect on modern furnace construction.

Dr. G. F. Huttig (Graz, Austria) summarized the work done at the technical University of Graz on problems of the preparation of pure titanium carbide. Modern principles of inorganic chemistry permit the selection of special gas atmospheres and of chemically active starting materials, and thus the preparation of titanium carbide of a composition closely corresponding to the formula TiC and of a very low free-carbon content.

Dr. R. Kieffer (Reutte, Tyrol) lectured on the formation of solid solutions of hard metals and covered the carbides, nitrides, borides and silicides of the fourth to sixth groups of the periodic system. The known solid-solution phases were reviewed. For the systems not yet investigated, it was predicted in which cases the formation of solid solutions can be expected.

Dr. R. Kiessling (Soderfors, Sweden) reported his investigations on ternary systems Me_1-Me_2-B and discussed the relative bonding strength between transition metals and boron atoms. The experimental work, which was done at the University of Uppsala, was limited to the systems manganese-iron-boron, manganese-cobalt-boron, manganese-nickel-boron and iron-cobalt-boron. It was found that in these systems the metal with

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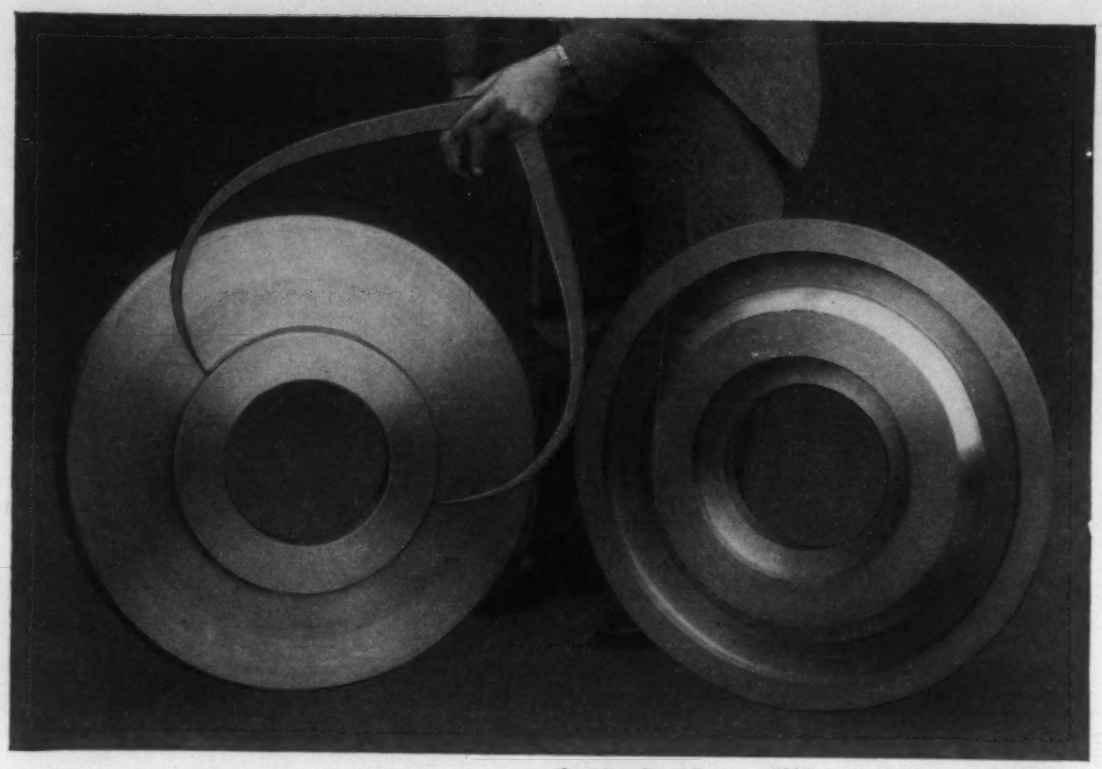

Stainless Steel Flange 2 1/16" thick x 28 5/16" OD x 9 3/4" ID

forged in stainless steel and rough machined by G. O. CARLSON, INC.

By working exclusively in stainless steels, the Carlson organization has an expert's knowledge and experience in the field. This is important whether you need plate (large or small, straight or cut-to-pattern), diameters, heads, rings, forgings or other stainless products.

The illustration shows (in a front and back view) a typical forging made of stainless steel. This flange was forged of Type 316 stainless and rough machined in our plant. The customer, by using this Carlson service, was able to finish-machine the part in record time . . . and shipping charges and material waste were held to a minimum.

As just one segment of our over-all service in stainless steels, G. O. Carlson, Inc. produces forgings in all sizes and analyses to chemical industry standards—rough machined, ready for finishing.

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News Digest

the lowest atomic number invariably is concentrated in the phase with the highest boron content. It was concluded that the strength of the metal-boron bond decreases with increasing atomic number of the metal.

Dr. J. T. Norton (Boston, Mass.) presented the results of his investigation of the ternary system tungsten-carbon-cobalt. The ternary isothermal section at 2552 F showed, in addition to the eta phase, two new ternary phases corresponding approximately to the formulae $Co_3W_6C_4$, respectively. The proposed phase diagram was the basis of a detailed discussion of the reactions taking place during the sintering of tungsten carbide-cobalt.

Dr. R. Edwards (Manchester, England) presented a paper by T. Raine and R. Edwards on the solid solubilities at 2282 F of various carbides in the bonding metals cobalt, nickel and iron. The solid solubilities of the carbides of tungsten, titanium, molybdenum, vanadium and cobalt and of titanium carbide-tungsten carbide solid solutions in the three bonding metals were determined by metallographic as well as by x-ray methods.

Dr. Onitsch-Modl (Leoben, Austria) lectured on the microhardness test employed as an auxiliary for the elucidation of changes taking place during the sintering of complex systems. Alloying processes taking place during sintering and involving hardness changes could readily be followed by microhardness measurements. The author presented the results of experiments on iron-carbon alloys containing the carbide-forming elements chromium, tungsten, molybdenum and vanadium. She discussed in detail the applicability of microhardness testing as supplement for metallographic methods, and particularly the limits of this method.

General Powder Metallurgy

Dr. F. V. Lenel (Troy, N. Y.) discussed some observations on the mechanism of liquid-phase sintering. On the basis of experimental results obtained with iron-copper, copper-bismuth, copper-lead and tungsten-copper, powder mixtures, the mechanism of sintering and densification was discussed. Special attention was given to the conditions

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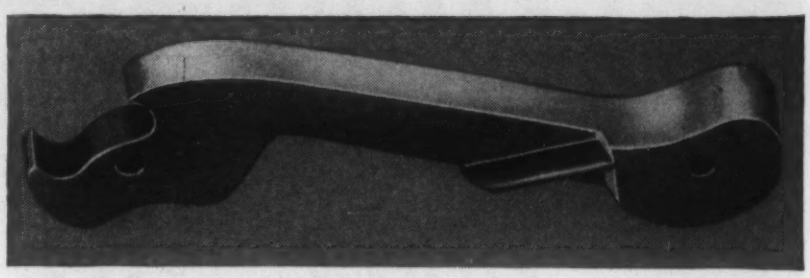
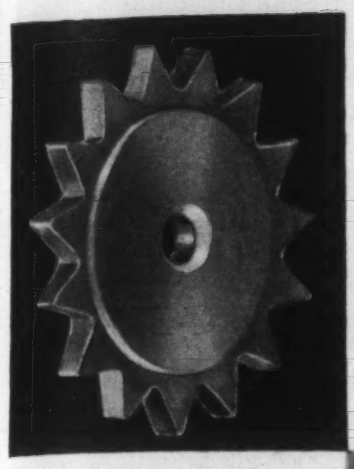
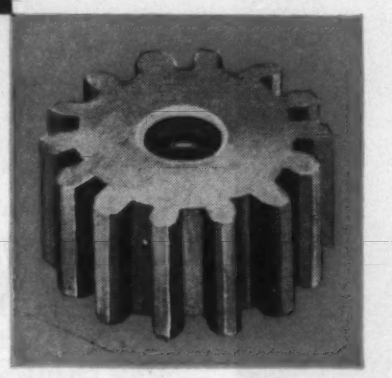


Alarm actuating mechanism for small clock. Clock parts are shown by courtesy of The Lux Clock Manufacturing Co.



Crown Wheel for small clock movement



Winding Pinion for automotive clock movement

Formerly machined in several operations, two of them requiring assembly, these parts are now made of iron powder in a single pressing operation... and product quality is improved. Sintering after pressing gives specified hardness and tensile strength with tolerances as close as .001".

Note the alarm-actuating mechanism with its 11 radii, two through-holes, different levels, etc., . . . a forbiddingly tedious and expensive job by machining and assembly. In powder metal it is as easily made as the simple pinion gear.

Powder metal processing makes this and many other parts at mass production speed . . . without scrap loss . . . at tensiles as high as 70,000 psi (over 100,000 with copper infiltration) . . . at hardnesses to 400 Brinell . . . at savings as great as 80% over previous methods of manufacture. Send for your copy of a free brochure, "Powder Metallurgy Today." Detailed data sheets are available on many parts, including those illustrated.

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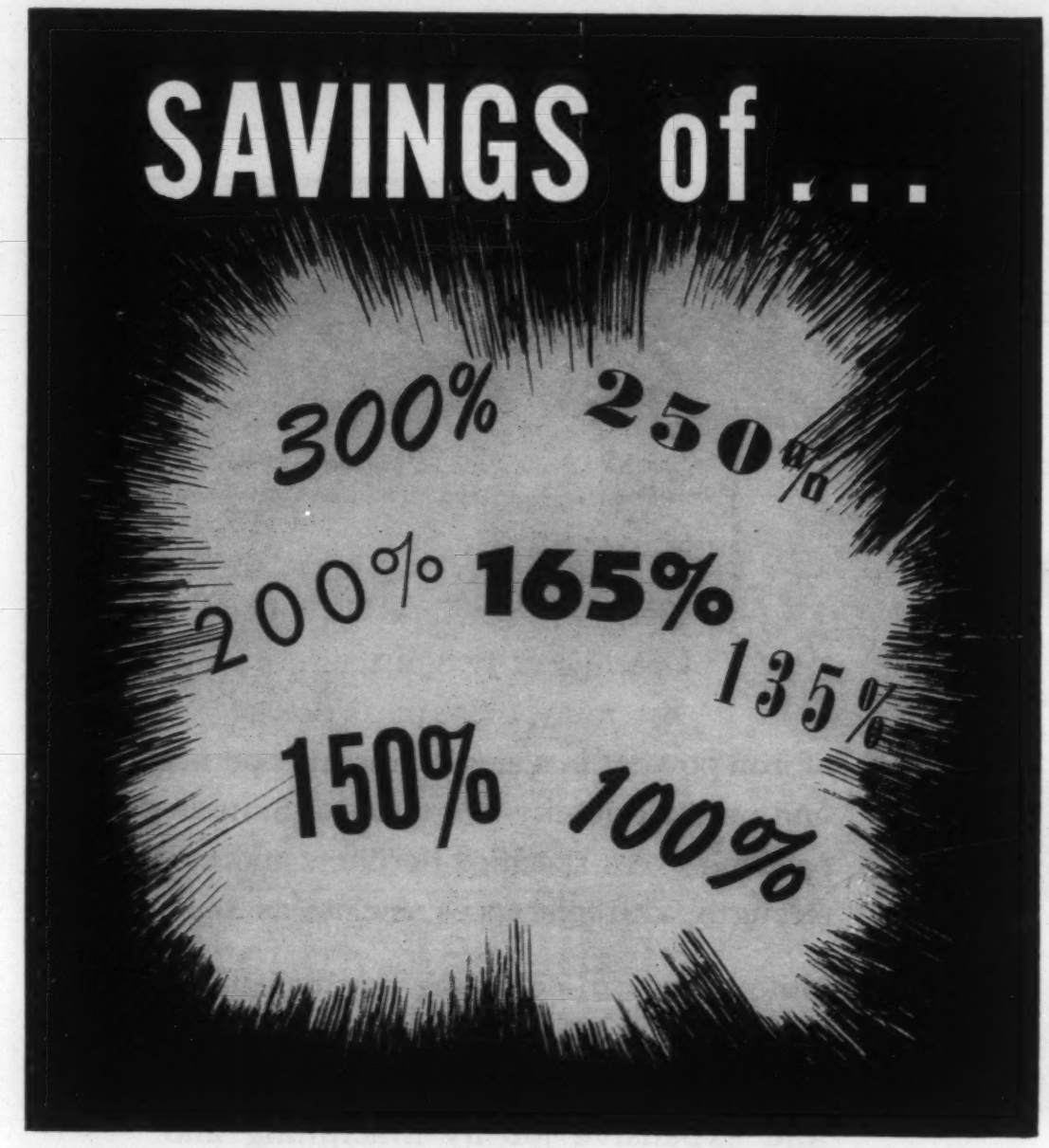

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News Digest

for the formation of rigid skeletons.

Professor G. J. Comstock and Dr. F. H. Clark (Hoboken, N. J.) reported on the development of high strength, heat treatable products from alloy powders. The authors consider the development, production and application of fully alloyed metal powders as one of the most significant factors in widening the field of powder metallurgy. The experimental results presented are in full agreement with similar results obtained in Europe.

Dr. Cremer lectured on the determination of the adhesive force of metal powders. The adhesive force is determined by measuring the glide angle of a powder dusted on a solid support, depends on the surface characteristics of both powder and support, and is in general inversely proportional to the average particle diameter of the powder.

Dr. H. H. Hausner (New York, N. Y.) lectured on the effect of lattice changes on the sintering process. The effects of lattice changes due (1) to reduction reactions, (2) to decomposition reactions, and (3) to phase changes are discussed. Experimental work described in this paper is concerned (1) with the effect of heating nickel powder compacts in a stream of H_2, (2) with the effect of heating zirconium hydride powder compacts in a vacuum, and (3) with the thermocycling of iron powder compacts around the phase transformation temperature. Significant effects of the lattice changes can be demonstrated in all three cases.

A. J. Langhammer's (Detroit, Mich.) talk on American production methods was of special interest for the European participants of the Seminar.

Dr. G. Ritzau's (Krefeld, Germany) lecture on the physical analysis of the sintering process demonstrated that the course of the sintering process can, in many systems, be followed by measuring the thermoelectric potential.

Special attention was given to the paper by Dr. A. von Zeerleder (Neuhausen, Switzerland) on new developments in the powder metallurgy of aluminum. The author gave a detailed report on the production of SAP (Sintered Aluminum Powder) products. These materials appear to extend the applicability

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Cruising down a modern highway in our new 1952 automobile gives us little cause to remember that COPPER is serving us faithfully in at least 45 parts of our present-day car. Copper aided in the development of the modern automobile from a mechanized buggy to the sleek mechanical perfection we drive today. So much so, that today this nation owns 45-million vehicles, and 25-million cars will take vacationists 150-billion miles of travel this year alone, barring wartimes.

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Important in this national application of copper and in every use to which copper is applied today . . . is HUSSEY COPPER . . . an all-American product since 1848.

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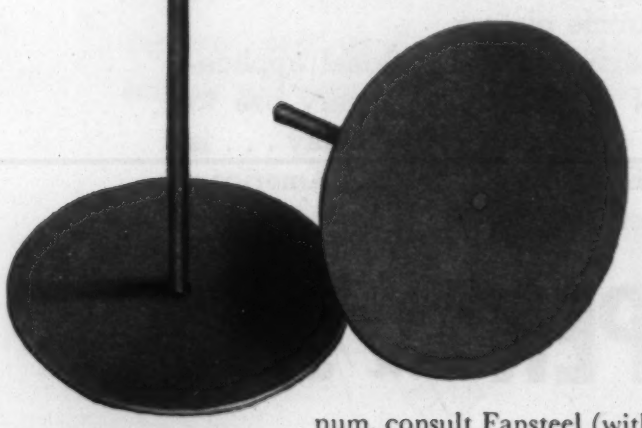
Whether you want semi-fabricated blanks or completely finished parts, you will save by letting Fansteel fabricate your tungsten and molybdenum components for you. Fansteel maintains complete facilities for fabricating, including forming, stamping, bending, deep drawing, forging, machining, brazing, welding, assembly and finishing. You'll find Fansteel engineering assistance valuable, too. Fansteel engineers are long experienced in the fabricating techniques peculiar to tungsten and molybdenum, and are well prepared to design parts with the minimum amount of metal and lowest fabricating costs.



Anodes for hydrogen thyratron electronic tubes. The disks are heavy molybdenum sheet. The shafts are made of tungsten rod.

If you are a user of tungsten and molybdenum, consult Fansteel (without obligation) for assistance in design and most economical fabrication.

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News Digest

of aluminum to the temperature range between 392 and 752 F. The starting material is a fine, superficially pre-oxidized aluminum powder. The powder is cold-prepressed at 28,000 to 70,000 psi, sintered at 932 to 1112 F, hotpressed at 70,000 psi, and then either directly die-forged or first extruded at (932 to 1112 F and 70,000 to 140,000 psi) and then die-forged or hot-swaged. The strength of the material reaches values exceeding 50,000 psi. The hot-strength of the unalloyed aluminum product is remarkable and by far exceeds all values reported for aluminum alloys. The superior creep resistance and also high temperature fatigue strength is attributed to the fact that the fine oxide films covering the individual powder particles prevent grain growth.

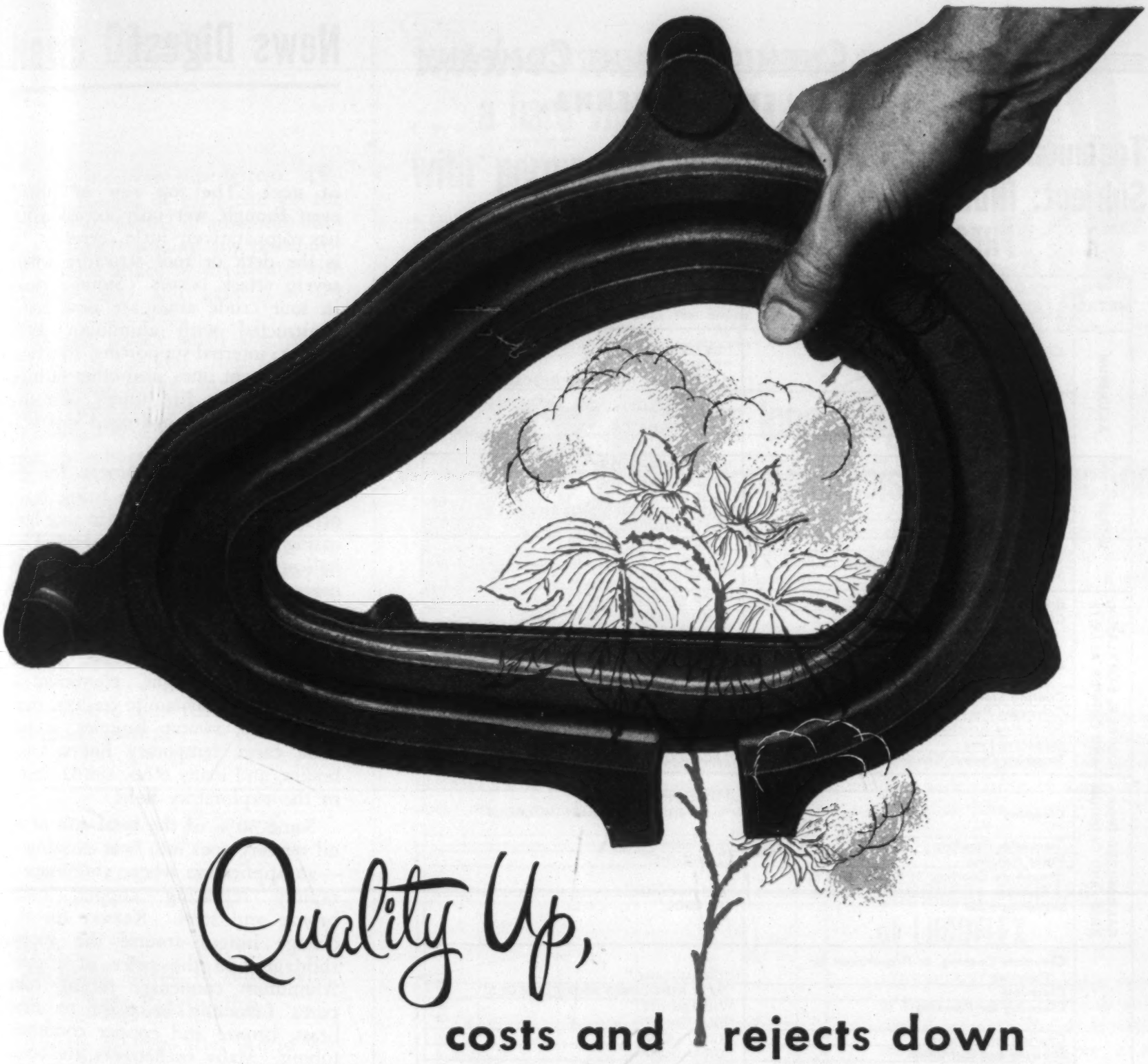
Oil Industry Becoming One of Largest Aluminum Users

Surveys and research by the Reynolds Metals Co. indicate that within a few years the oil and gas industry will become one of the largest users of aluminum.

Oil field structures, such as servicing units and drill rigs, are too heavy to be mobile and portable. The dead weight of a truck mounted servicing unit for installation makes it, in many cases, impossible to move such units into swamps and uneven terrain. In many states, it is illegal to operate such units on state and federal highways at their present weight. By designing with aluminum, up to two-thirds of the weight of these units can be eliminated while still providing all the strength and rigidity of the original unit.

In sour crude areas, certain oils contain sulfur gases that escape during storage to combine with moisture in the air and form sulfuric acid. This liquid is very corrosive and severely attacks steel.

When such oil is stored in tanks, it has been found that the tank sides are not corroded to any great extent by the oils, so they are made



Quality Up, costs and rejects down WITH CRUCIBLE TOOL STEEL CASTINGS

The steel part shown above used to be a production headache. A cam for a cotton picking machine, it was originally flame cut from SAE 8730 boiler plate, machined and heat treated. Other difficult steps included end-milling and finish-grinding the cam track. Rejections were high, because the cam often warped during heat treatment.

The problem was solved by casting the cam in Airkool®, a Crucible air-hardening tool steel. When the customer receives the casting from Crucible, all he has to do is finish it, mill the cam track and heat treat. He doesn't have to finish grind — Airkool is non-deforming when properly hardened and tempered. Machining costs are way down and quality is up, since Airkool resists wear far better than the low alloy steel from which the part used to be made.

Crucible's casting facilities often make it possible to use wear- and abrasion-resisting tool steel for complicated machine parts. We may be able to help you just as we helped the cotton picking machine manufacturer. Get in touch with Crucible today!

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Technical Service Data Sheet

Subject: INDEX OF ACP CHEMICALS FOR METAL PRESERVATION AND PAINT PROTECTION

METAL	OPERATION	ACP CHEMICAL
ALUMINUM	*Cleaning*	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Preparation for Painting	"ALODINE" "DURIDINE" "DEOXIDINE"
	Protection from Corrosion	"ALODINE"
BRASS	*Brightening*	"ACP BRIGHT DIP"
	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "CUPROTEK
	Corrosion Prevention	"CUPROTEK"
	Soldering Flux	"FLOSOL"
COPPER, BERYLLIUM, AND COPPER ALLOYS	*Brightening*	"ACP BRIGHT DIP"
	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "CUPROTEK"
	Coating Steel with Copper	"CUPRODINE"
	Corrosion Prevention	"CUPROTEK"
	Scale Modification	"RIDOXINE"
	Soldering Flux	"FLOSOL"
	Stripping Copper Coatings	"ACP COPPER STRIPPING SOLUTION"
GALVANIZED IRON, ZINC, AND CADMIUM	*Cleaning*	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Corrosion Proofing	"ZINODINE"
	Paint Bonding	"ZINODINE"
	Phosphate Coating, in Preparation for Painting	"LITHOFORM"
	Soldering Flux	"FLOSOL"
IRON AND STEEL	*Chromate Coating, in Preparation for Painting*	"CROMODINE"
	Cleaning	"ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "DURIDINE"
	Coating with Copper	"CUPRODINE"
	Drawing and Extrusion	"GRANODRAW"
	Paint Bonding	"CROMODINE" "DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Paint Stripping	"CAUSTIC SODA AND SOLVENT NO. 3"
	Phosphate Coating, in Preparation for Painting	"DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Phosphate Coating, to Protect Friction Surfaces	"THERMOIL-GRANODINE"
	Pickling with Inhibited Acids	"RODINE"
	Rust Prevention for Unpainted Iron	"PEROLINE"
	Rust Proofing	"PERMADINE" "THERMOIL-GRANODINE"
	Rust Removal—Brush, Dip, or Spray	"DEOXIDINE"
	Soldering Flux	"FLOSOL"
MAGNESIUM	*Cleaning*	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Pickling	"RODINE (M-200)"
STAINLESS STEEL	*Cleaning*	"DEOXIDINE"
	Coating with Copper	"CUPRODINE"
	Pickle Polishing	"RODINE"
	Soldering Flux	"FLOSOL"

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News Digest

of steel. The top row of plates, even though wet only occasionally, has comparatively little corrosion. It is the deck or roof structure where severe attack occurs. Storage tanks in sour crude areas are now being constructed with aluminum decks (roof), internal supporting structure, hatches, vent lines, and other fittings, insuring long life under corrosive conditions where hydrogen sulfide is encountered.

Much special equipment for exploratory work is now being made of aluminum. Light-weight shot-hole casing that can be transported in helicopters is becoming more and more popular. It costs little more than steel. A 100-ft string of aluminum shot-hole casing weighs approximately 60 lb. Also, because of its light weight, aluminum is being used in dynamite trailers, shot-hole drills, swamp buggies, instrument cases, temporary liners, truck bodies, and many other similar items in the exploratory field.

Some 30% of the total cost of an oil refinery goes into heat exchangers —an application where aluminum is rapidly replacing copper, brass, bronze and steel. Reason for this change hinges around the copper shortage and the price of copper. Aluminum condenser tubing compares favorably in price to steel, brass, bronze and copper condenser tubing. Many exchangers are being built using aluminum fin stock and copper tubing. All-aluminum heat exchangers are also being developed rapidly due to recently improved aluminum brazing techniques which greatly facilitate the joining of the heat exchanger fins, tubes and supporting framework.

The light weight of aluminum gives it an advantage when installing pipe lines through swamps, over mountain ranges, lakes, oceans, and river crossings. A number of river crossing installations have been made, including a 10¼-in. dia, 3/16-in. wall gathering line carrying sweet natural gas at pressures up to 250 psi across the north fork of the Little Colorado River near Bowie, Okla. This river crossing uses eleven 30-ft sections of extruded aluminum pipe with ends beveled 30 degrees for welding. A single 1¼-in. steel cable

(Continued on page 187)

supports the entire pipe system. Aluminum flanges at each end of the crossing are bolted to adjoining steel line flanges, avoiding any possibility of galvanic attack by insulating with Micarta tubes and gaskets at the flanged connections.

At first glance small size tubing ranging in diameter from 1/2 to 5/8 in. appears to be an insignificant item. Actually, however, thousands of miles of this tubing are used each year in refineries, chemical plants, gas processing plants, and other industrial installations. Aluminum tubing is replacing other materials for this work. Aluminum tubing performing as well as other materials is in many cases as much as 40% cheaper. Also of interest is its resistance to normal outdoor exposure and its ability to withstand the hydrogen sulfide present in the atmosphere around most refineries and gas processing plants.

Tin Being Saved in Automobile Body Construction

The tin shortage after World War II radically changed the composition of many materials of which tin was a major component, according to a paper by Homer C. Pratt, Fisher Body Div., General Motor Corp., presented at the American Society of Testing Materials symposium held recently in New York City. This was especially true in automobiles. The history of automobile body solder is one example. The amount of tin used to solder a body was cut from 1.00 to 0.18 lb.

Torch soldering, used to seal and fill joints and welded seams between stamped sections of the body, consist of two phases: (1) tinning; and (2) filling. Tinning is the application of a thin solder film to the surface. Filling is the building up of the area to the proper contour. The tinning solder must wet the metal, resist oxidation at working temperatures and be compatible wtih the filler material. Before 1946, the

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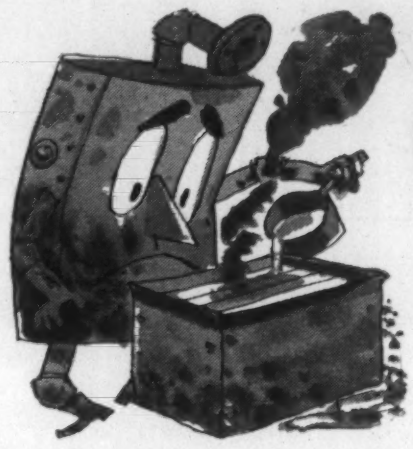

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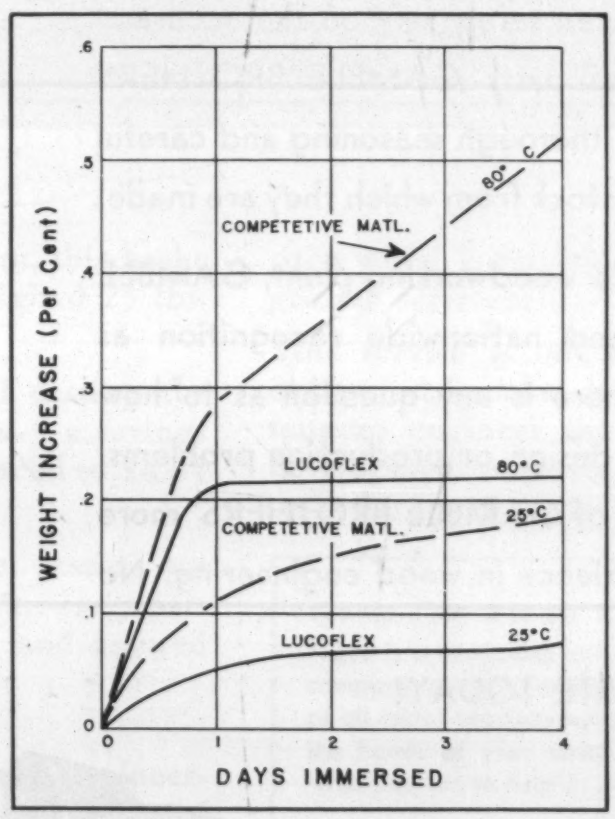
LUCOFLEX, a new *unplasticized* polyvinyl chloride engineering material, achieves a new high in life/cost ratio for corrosion resistant construction. Because of its permanent properties, it can supplant more costly plastics which are often difficult to fabricate and mold. LUCOFLEX is supplied in sheets, rods, and tubes, and in a wide variety of shapes and sizes—it is machined, formed, welded and cemented with simple shop techniques.



Chemical resistance of LUCOFLEX

LUCOFLEX is chemically inert to most inorganic chemicals and certain organic materials as well. At ordinary temperatures it is practically unaffected by all mineral acids, bases and salts, chlorine, greases and oils, alcohols, and carbon tetrachloride. At both room and elevated temperatures (170 C) its chemical resistance is superior to all competitive vinyl polymers, as shown in this chart of comparative resistance to immersion in 15N nitric acid.

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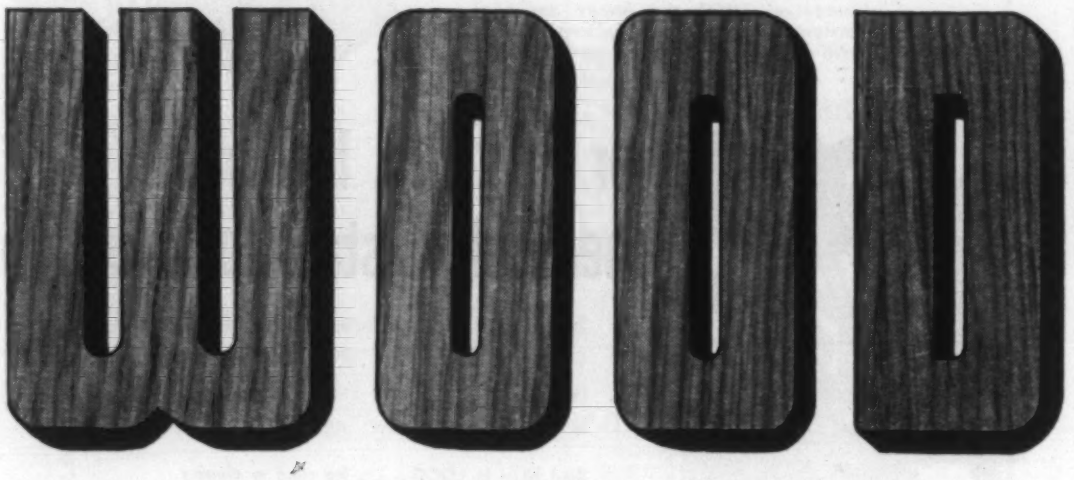
Among the gears, shafts, and fly wheels of industry are the many spools, spindles, rollers, knobs, and handles which make the machines complete. Time and again experience has proved that of all the materials available for these uses, first choice is



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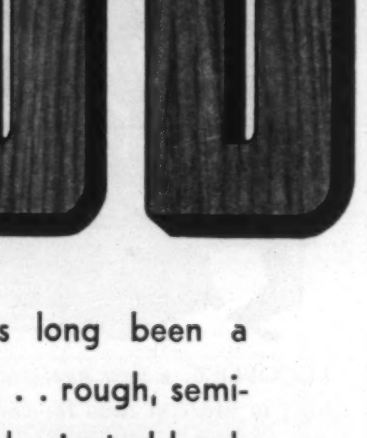

INCORPORATED

News Digest

Automobile Industry used a liquid flux and bar solder for tinning. A typical flux consisted of 32 zinc chloride, 8 ammonium chloride, 3% hydrochloric acid, with the balance water. The tinning solder was the same as filling solder. The nominal composition was 20 to 30% tin and the balance lead.

The industry tried to save tin in two ways. Low tin alloys (10%) with antimony, arsenic, silver, indium and bismuth oxidized too easily. A more successful approach was to reduce the amount of solder required to do a job.

Powdered solder mixed with powdered flux and water was brushed on to surfaces to be tinned and the surfaces were heated. This cut the amount of solder which fell to the floor and saved 50% on solder.

Before World War II, filling solder contained 15 to 50 tin, 1% maximum antimony and the balance lead. When the tin shortage came, it was found possible to use lower tin alloys without harm. The solder now used is nominally 4.0 to 5 antimony, 2.5 to 4 tin, 0.60% maximum arsenic and the balance lead. The antimony lowers the melting point and gives a suitable plastic range. The tin provides wetting action. Arsenic refines the grain. This solder does not harm body point and is dimensionally stable in aging. The use of this composition resulted in an 87% reduction in the amount of tin required for filler material.

Shop Practices to Be Discussed at Porcelain Enamel Forum

More than 300 persons are expected to be present at the 14th Annual Shop Practice Forum, to be held this year at the University of Illinois, Urbana, Ill., on Sept. 10, 11 and 12. At least 50 authorities will participate in this three-day program. This yearly event, which is held alternately on the campuses of the University of Illinois and The Ohio State University, is being co-spon-

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When produced as a weldment, this brake spider for power shovels weighed 25 lbs. and cost $7.35.

By redesigning it to a steel casting the weight was reduced to 20 lbs.—a savings of 20%, and the cost was reduced to $4.84—a savings of 34%.

Other advantages of the steel casting are good appearance—desirable for *every* part of a well designed product, and assured dependability.

* * *

Here is another example of the engineering teamwork in design and redesign of parts which is resulting in lower costs and greater serviceability with steel castings.

This service is offered without cost or obligation. It makes available through your foundry engineer the full results of the development and research program carried on by the Steel Founders' Society of America.

Keep The Scrap Coming Back . . .
There is a continuing need for steel scrap. Your company can help maintain the high production of all metal products by getting your scrap into the hands of your scrap dealer. Will you do what you can to help . . . now?

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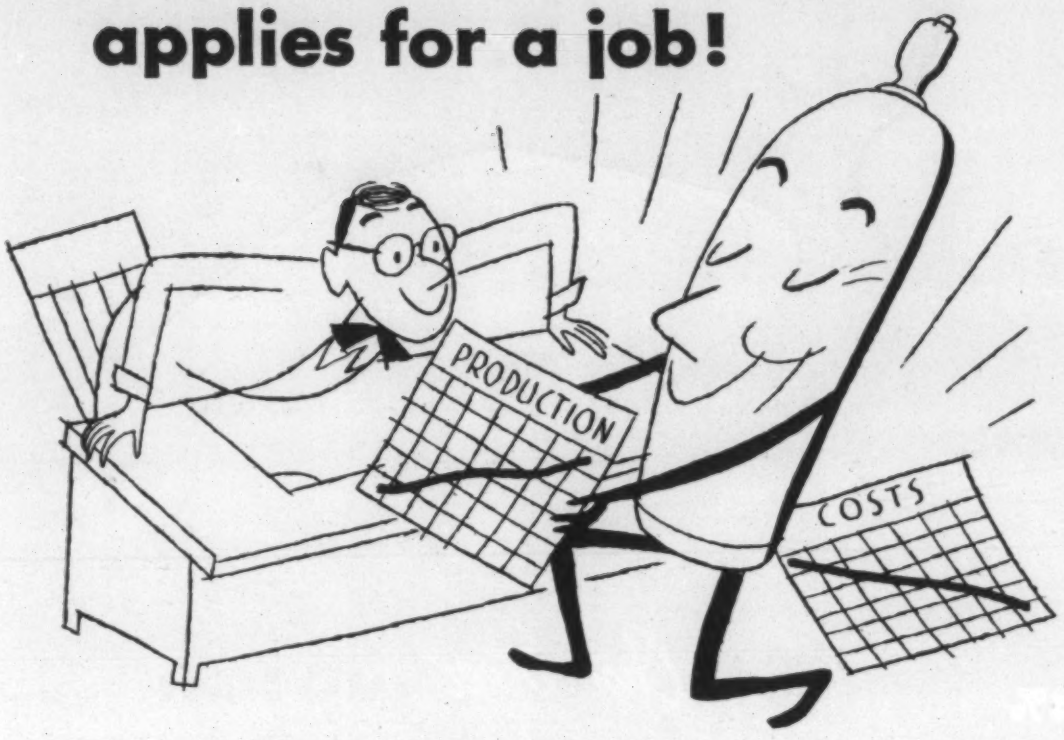
920 Midland Building Cleveland 15, Ohio

Design and Build With Steel Castings

Amazing Ammonia

applies for a job!

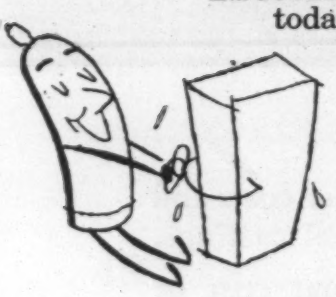


If ammonia, the versatile chemical, applied for a job, the interview would probably go like this:

EMPLOYER: How old are you?

AMMONIA: Many centuries. I helped the ancient Egyptians bleach cloth 3,000 years ago.

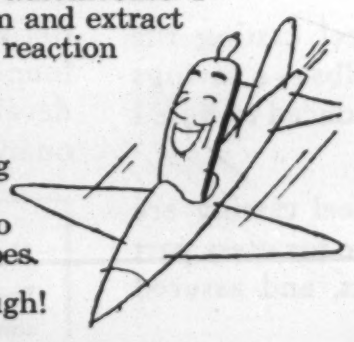
EMPLOYER: Amazing! But what do you do today?



AMMONIA: I grow farm crops, make ice, purify water, produce explosives.

EMPLOYER: I know you are a fertilizer, a refrigerant, and . . .

AMMONIA: Yes, and I serve as a protective atmosphere to surface-harden and anneal vital parts of planes and automobiles. I neutralize acid in petroleum and extract metals from ores. I'm a solvent and reaction medium in organic synthesis, a nutrient for yeast and a processing agent in the manufacture of alkalis, rayon, dyes, butadiene, and catalysts for cracking petroleum. I'm used in making vitamins, sulfa-drugs and radio and television parts and tubes.



EMPLOYER: Whoa—that's enough! What can you do for us?

AMMONIA: Just let one of our technical men talk it over with your chemists. He can usually find an answer that will speed up some process and save you dollars.

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News Digest

sored by the University of Illinois' Dept. of Ceramic Engineering, headed by Dr. A. I. Andrews. General chairman of the event is R. L. Fellows, Chicago Vitreous Enamel Product Co.

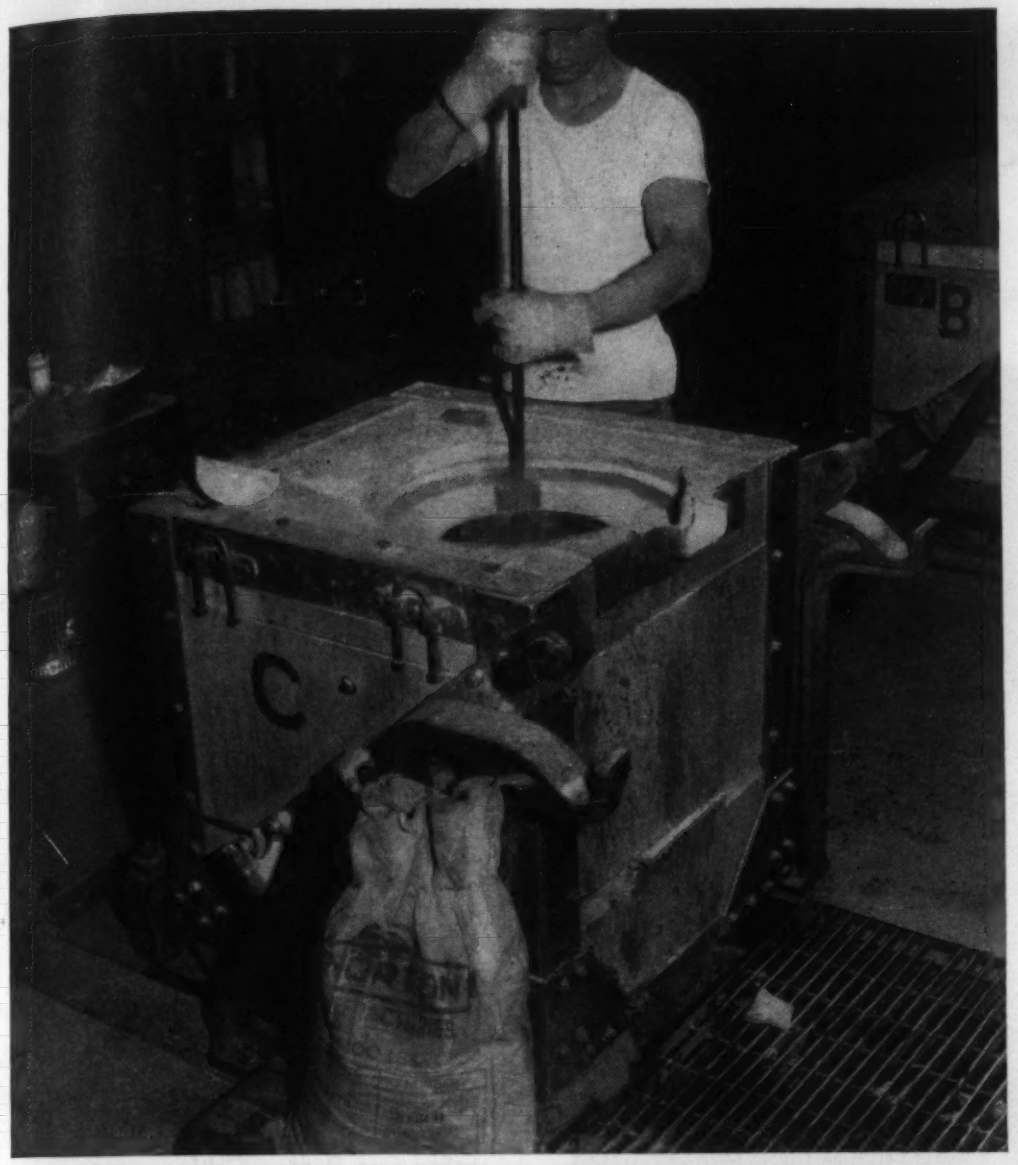
In the opening session on Wednesday, Sept. 10, 14 technical persons will present papers on various topics under the heading "What's New in the Industry". The morning session on Thursday will deal with the various phases and innovations relative to the enameling of aluminum and steel, with the afternoon segments covering such interesting subjects as high temperature ceramic coatings, alkali resistance of enamels and new uses for porcelain enamel. Thursday's session will close the annual banquet, with Dr. George Stoddard, President of the University of Illinois, as speaker. Control practices in the enameling industry will be the primary subject during the Friday morning meeting, with representatives from five different types and sizes of enameling plants to discuss controls which are practiced in their respective organizations, after which a paper dealing with torsion testing as an aid in process control will be read.

The three-day Forum will conclude with the "Board of Experts", a group of industry authorities, to which the audience will submit their enameling problems.

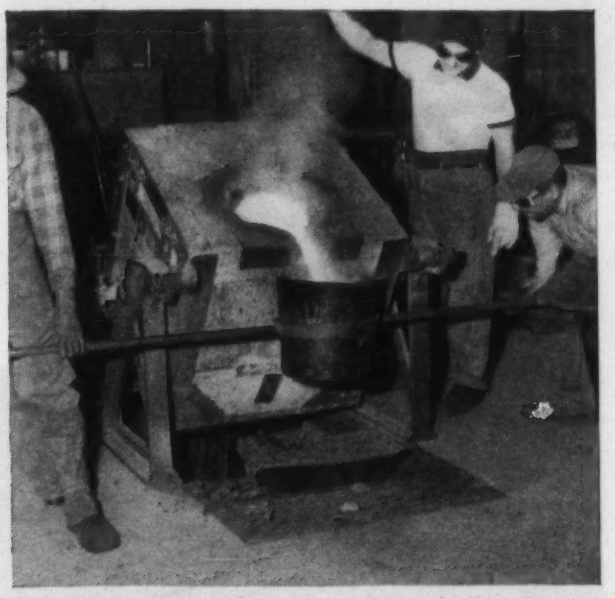
Porcelain Enamel Institute Lists Research Activities

Current research and experimental activities of the Porcelain Enamel Institute include nine separate projects being conducted either by the Research Fellowship at the National Bureau of Standards or by subcommittees of the Institute's Quality Development Committee.

Problems under study by the permanent research fellowship sponsored by the Institute include a revision of the tentative standard "Torsion Test for Laboratory Specimens of Porce-



RAMMING Norton MAGNORITE cement lining into an Ajax 500-lb. high frequency induction furnace. This cement has been developed specifically to be dry rammed and will withstand temperatures up to 3250 F. It provides densest possible lining for resistance to metal penetration and erosion.



MOLTEN STEEL is here poured into ladles. Due to the employment of fractional tapping, cement lining must withstand much longer periods of holding melt at pouring temperatures. Highly refractory Norton MAGNORITE cement insures long life and low maintenance cost even under these conditions.

MAGNORITE CEMENT LINING shows no evidence of erosion or chemical attack after metal has been completely poured, thus assuring minimum repairs. This cement is designed to have a slight expansion upon maturing to eliminate shrinkage cracks which might lead to furnace failure.

Melt more metal per lining

with Norton Refractory cements

You'll get long life, low maintenance cost from your furnace linings by using Norton refractory cements. *You'll melt more metal per lining.*

These cements are available in a variety of refractory compositions designed to meet your individual needs. *Norton MAGNORITE* cement,* for instance, is used in high frequency furnaces for a wide variety of melts, ranging from straight steels to heat-resistant compositions. *Norton FUSED STABILIZED ZIRCONIA* crucibles are excellent for melting platinum and its alloys. This sensational refractory is not wetted by the metal, permitting 100% recovery of the melt without destroying the crucible. *Norton ALUNDUM* and MAGNORITE* crocks, covers, and cements are used successfully in indirect arc furnaces. These cements are also used in low frequency furnaces for melting such refractory alloys as cupro-nickel and nickel silver; high copper alloys and Al, Te, and Si bronzes. *ALUNDUM* cement is also excellent for handling stainless steel.

For heat-treating and sintering furnaces investigate ALUNDUM and CRYSTOLON* hearth plates, pier brick, burner blocks, muffles, muffle plates, skid rails, recuperator tubes, burner-tunnel, and embedding cements.

Whatever your problem, you can depend on satisfactory solution when Norton research engineers Norton refractories to fit your exact requirements. For further information, see your nearby Norton representative — or write direct to NORTON COMPANY, 346 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.

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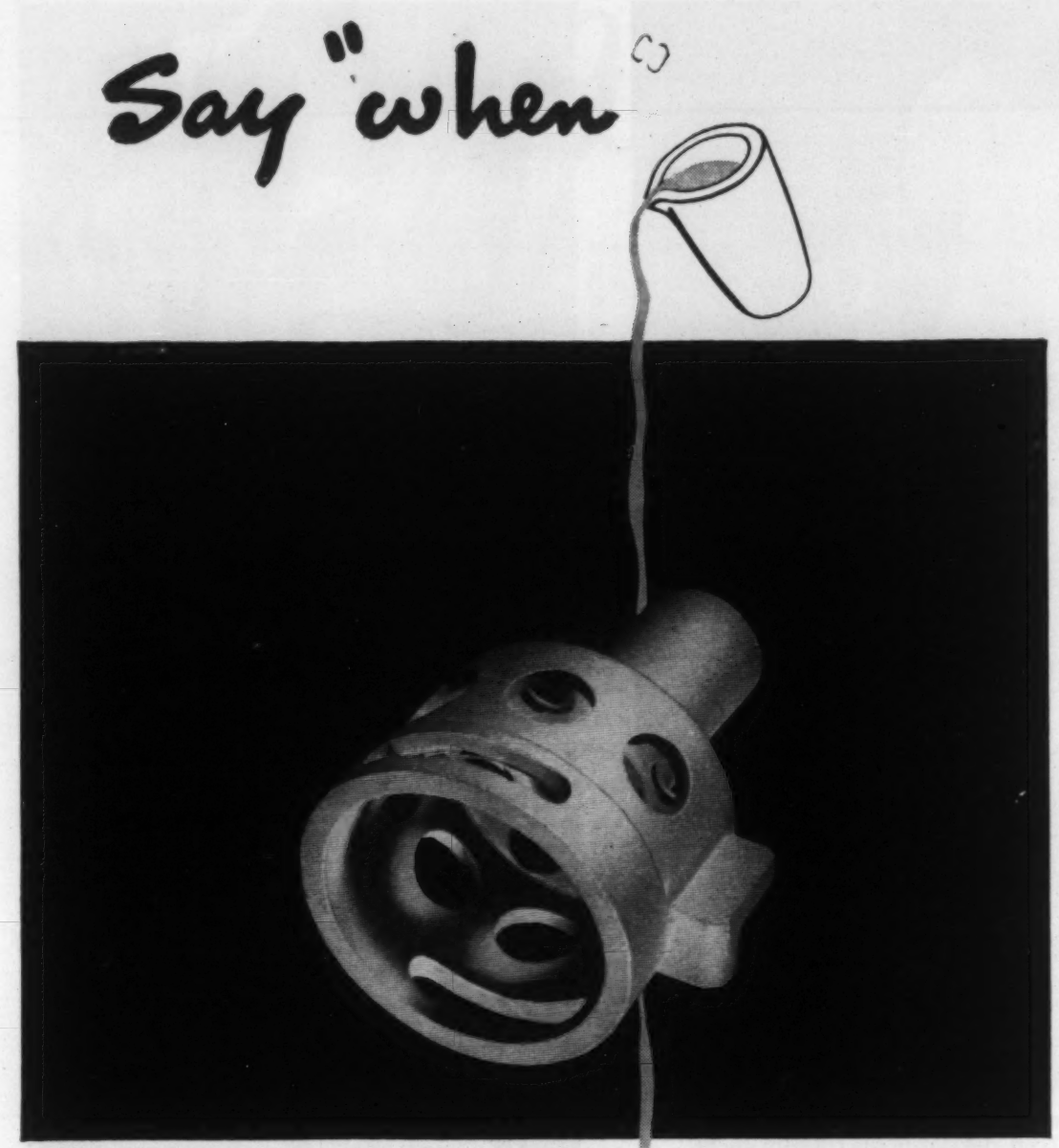

We make this part by *Investment Casting* —the expendable pattern process.

In quantity, it costs $2.80. Produced in any other way, it would cost 3 to 4 times as much.

Because such pieces can be cast in one piece, they frequently replace complicated assemblies. They often need no premachining and finishing operations.

We cast in almost any shape—simple and complex—and in 160 different ferrous and nonferrous alloys.

Tolerances are extremely close; details are fine. Castings run from a fraction of an ounce to 5 pounds.

Here's a booklet to give you ideas

Our engineers are skilled in designing parts as investment castings, as well as producing them. More details about this versatile process are explained in a new booklet, "Pour Yourself an Assembly". Send for your copy. There's no obligation, of course. Precision Metalsmiths, Inc., 1073 E. 200th St., Cleveland 17, Ohio.

when it costs too much to machine

when you need an alloy that won't machine

when you're looking for more freedom of design

pour yourself an assembly with

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INVESTMENT CASTINGS

News Digest

lain Enameled Sheet Iron and Steel"; the correlation of resistance of porcelain enamels to surface abrasion, subsurface abrasion, scratch and gouge; and a revision of the standard "Test for Resistance of Porcelain Enamels to Surface Abrasion."

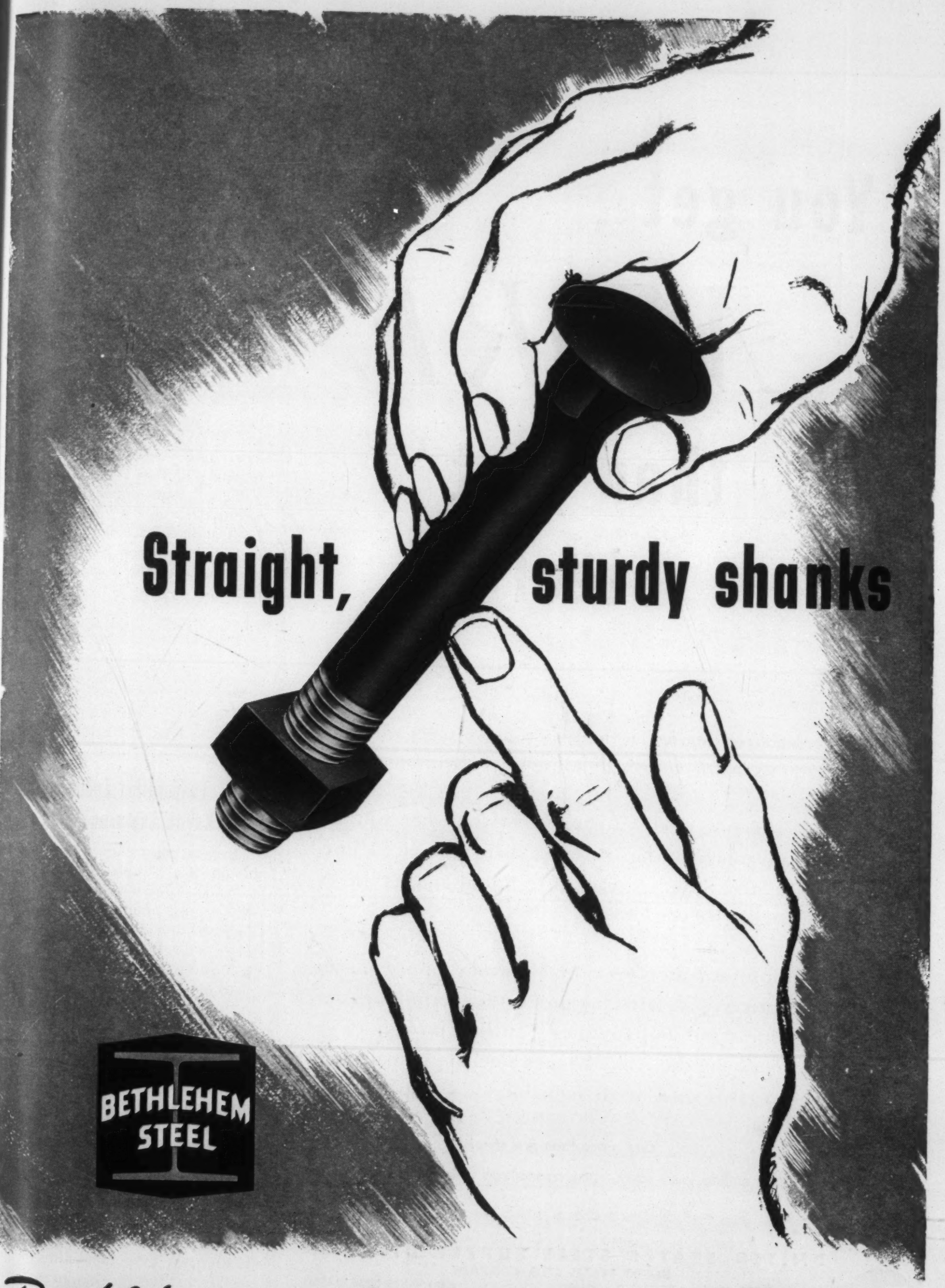
In addition, various subcommittees of the Quality Development Committee are engaged in the following projects: a restudy of the tentative standard "Test for Sagging of Iron and Steel Sheets for Porcelain Enameling"; a restudy of the tentative standard "Impact Test for Laboratory Specimens of Porcelain Enameled Sheet Iron and Steel"; a standardized test for gloss; statistical procedures and quality control; a standardized test for determining the alkali resistance of porcelain enamels.

Details of these various projects, according to PEI, will be announced as they are completed and approved by the Quality Development Committee, headed by G. H. Spencer-Strong of Pemco Corp.

Corrosion Engineers Discuss Oil and Salt Water Problems

Technical information on the prevention of corrosion of offshore oil well drilling structures and marine tankers, on how mill scale affects the corrosion rate of steel in salt water, and on the effect of bacterial corrosion in sea water are included in the program of the South Central Region, National Association of Corrosion Engineers' Oct. 1-3 meeting at New Orleans. The engineering information also includes data on the corrosion of oil refineries, gas condensate wells, and the protection of buried or submerged pipe lines from external corrosion with coatings or cathodic protection.

Eighteen technical papers in four symposia have been outlined by Technical Program Chairman John E. Loeffler of Thornhill-Craver Co., Houston. The meeting at the Jung Hotel also will include sessions of



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UNITED STATES STEEL

News Digest

NACE technical practices committees, a business meeting and various social events.

T. P. May and R. B. Teel, both with the International Nickel Co.'s Corrosion Engineering Section, will present a paper Oct. 2 on "Mill Scale on Steel and Its Effect on Steel Corcosion in Sea Water." This paper will be based on the extensive tests conducted by the International Nickel Co.'s Harbor Island and Kure Beach testing stations.

"The Oil Tank Ship and Its Corrosion Problems," by J. D. Sudbury and D. A. Shock, of the Development and Research Dept. of Continental Oil Co., Ponca City, Okla., will be given during the Oct. 3 technical session at the Jung Hotel. Both authors have had long experience with corrosion problems in connection with the handling of petroleum.

Evaporation Technique Key to Adhesion Studies

Evaporation techniques for the adhesion of electroplatings and solders to oxide-coated metals and glass have shown great progress at the Engineer Research and Development Laboratories, Fort Belvoir, Va.

Some metals are difficult to electroplate or solder due to poor adhesion to their natural hard, tenacious oxide coatings. When these coatings are removed, new oxides are immediately formed. Metals such as aluminum, chromium and titanium become coated with an oxide film even at room temperature in a vacuum at pressures less than 10—5 mm Hq.

It is desirable to secure adhesion to these metals by a process which includes their oxides. Excellent adhesion to these oxides can be obtained by high vacuum exaporation techniques. Evaporated films of most metals that form hard adherent oxide coatings can be caused to adhere tenaciously to their own and to other oxides, including glass. Evaporated films of some other metals, particu-

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Sawed	High corrosion resistance
Drilled	High heat transfer
Milled	Low electrical resistance
Broached	High thermal shock resistance
Turned	Not wetted by molten metals
Planed	Non-warping
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Plagued by Material Shortages?

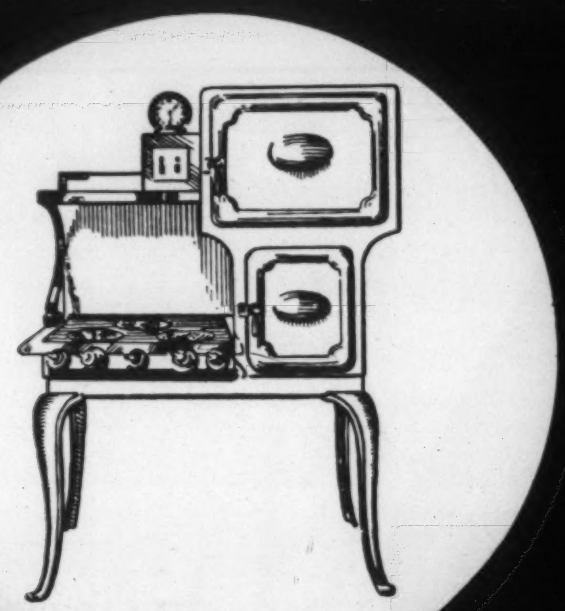
Carboneering—the development of new and unusual product applications for carbon—is a fifty year old habit at Speer, and one that may be able to help you.

Example: the rectifier grid developed by Speer engineers for a large electrical manufacturer. This 25-pound anode is over one foot in width, more than two feet in height. It was *extruded, machined,* and then had more than 600 holes *precision-drilled* in it. No doubt about carbon's versatility here.

For contrast . . . consider the small carbon window plate in X-ray equipment. It weighs only a few ounces and is under three inches in width and length.

These are but two of the many applications for carbon developed by Speer. If you have a design problem—or are faced by a shortage of critical materials—let our engineers go to work and help you *carboneer* a practical solution.

Send us the full particulars of your problem, today.



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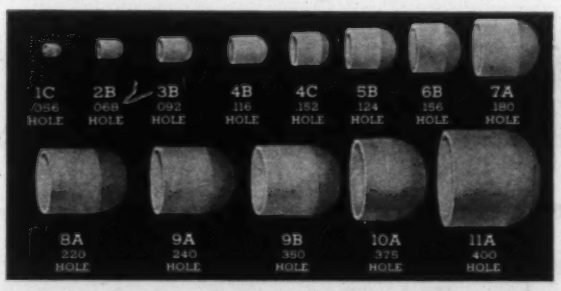
And today, it's the same story with the modern "flat-tops". Technical progress has been made also in STAR porcelain products. Long ago we discarded the "single formula" for ceramic insulation. Specific formulae, with various mechanical and electrical properties have been developed for hundreds of different applications. Make it a point to investigate STAR porcelain for the properties you need—physical and dielectric strength, thermal shock, moisture resistance, and others.



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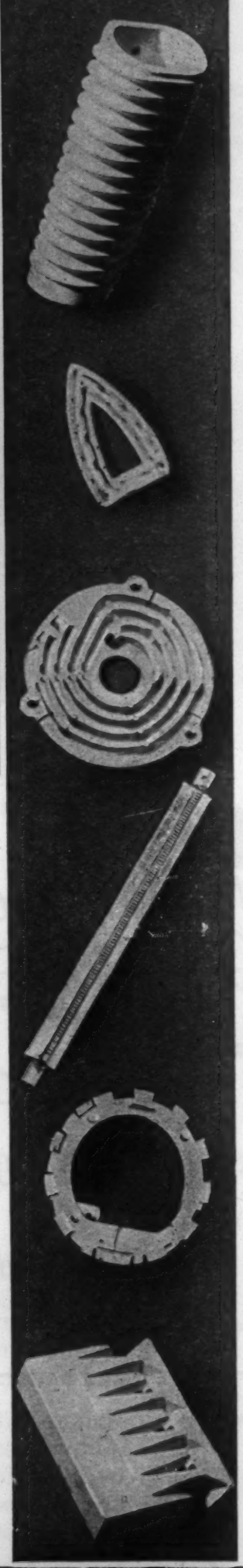
Ball and socket type for insulating bare wire. Heat resistant. High dielectric strength. Low cost. Quickly applied. 13 stock sizes. Cut shows beads approximately half size. Send for samples.



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The **STAR** PORCELAIN COMPANY

MUIRHEAD AND JAY AVES. TRENTON, N. J.

News Digest

larly gold, silver and copper, show poor adhesion to oxides. However, a metal of the latter group can be made to adhere tenaciously to a metal of the former group by high vacuum evaporation techniques.

The vapors of the two metals can be deposited simultaneously in such a manner as to eliminate the oxide coating which normally hinders adhesion. Thus, to coat titanium with copper, titanium is first evaporated on the oxide-coated titanium. At the first evidence of titanium deposition, the evaporation of copper is begun. At the first copper deposit, the titanium source is turned off and the copper evaporation continued until no titanium shows through the surface. The resulting surface can be soldered to directly or can be built up by electroplating. This method can be adopted to coating rolls or flat plates in a continuous coater.

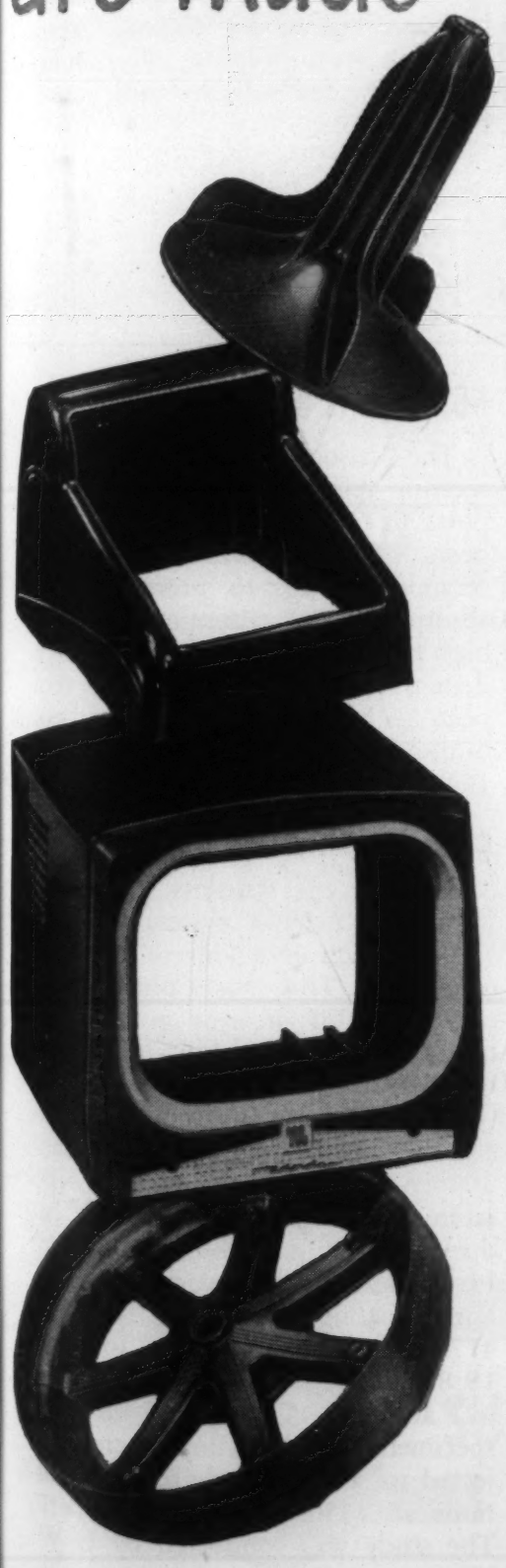
Responsible for the investigations on adhesion of evaporated coatings is Noel W. Scott, physicist in the Engineer Research and Development Laboratories, Radiation Branch, Fort Belvoir, Va. Referring to this new process, Mr. Scott said that outgrowths of the studies demonstrated that "—evaporated coatings can be used to advantage in processes for applying heat resistant coatings to metals, transparent conducting coatings to glass, and the manufacture of mirrors by a replica technique."

New Formula May Speed Development of High Temperature Materials

Development of high temperature materials may be greatly speeded up with a stress formula discovered recently by two metallurgical research engineers at the General Electric Co.'s Thomson Laboratory, Lynn, Mass.

G-E engineers say up to a year of test time can be avoided with the formula, which relates strength with time and temperature. The formula has been transformed into a calcu-

Where the BEST OF THE BIGGEST are made



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News Digest

lator that is operated like a slide rule. With data obtained on short time acceptance tests and the calculator, long-time strength of metals under high temperatures can be determined.

The capacity of creep and rupture equipment can be increased. Data at intermediate temperatures can be obtained without cross plotting, and complete rupture characteristics of an alloy can be represented by a single curve, facilitating comparison with other materials.

G-E engineers say the formula can be particularly helpful in the development of improved metals for turbosuperchargers, jet engines, steam turbines, steam piping, oil refining piping, guided missiles and atomic power plants.

NBS Reports on Materials Research

The National Bureau of Standards recently released several research reports of interest to materials engineers. These reports covered: (1) ceramic coatings to prevent carbon absorption; (2) chromium and glass high temperature coatings for molybdenum; (3) the effect of strain temperature history on the low temperature properties of ingot iron; and (4) the tensile properties of nickel.

Ceramic Coatings

Some of the stainless steels used in aircraft exhaust systems tend to absorb carbon under severe operating conditions. This causes precipitation of carbides at or near grain boundaries, which may result in failures of exhaust parts.

The National Bureau of Standards has demonstrated in recent laboratory tests that certain NBS ceramic coatings successfully prevent this undesirable carbon absorption. Investigated were several NBS ceramic coatings, including types A-417 and A-19H, applied to three 18:8 stainless steels: AISI types 304, 321 and 347. Coated and uncoated specimens of the alloys were subjected to strongly carburizing conditions at 1350, 1500 and 1650 F. The study was conducted by J. W.

Case History M M-101

Here's what we mean by ENGINEERED FOUNDRY PRODUCTS...

PROBLEM:

1. It was impractical, from a cost as well as a delivery standpoint, to produce a welded fabrication designed by one of our customers.
2. Customer's Sales Departments met with sales resistance due to poor appearance of part.
3. Fabricated part lacked necessary strength.
4. Customer's machine facilities were not adequate to handle numerous parts required by fabrication.

OUR ANALYSIS:

1. A steel casting would be practical as quantities were too small to afford forging dies, too large for economical production by welding.
2. As a one-piece steel casting, appearance of part would be greatly improved.
3. Metal distribution must be corrected to obtain needed strength.
4. Excessive machine stock must be eliminated, part must be readily machined in semi-production quantities.

OUR SOLUTION:

1. Designed steel casting that could be made rapidly from relatively inexpensive pattern equipment.
2. "Eye appeal" was achieved, see lower view, thus overcoming sales resistance.
3. FOUNDRY ENGINEERED DESIGN resulted in a homogeneous steel casting having metal distributed where it would be of most value.
4. Parts were machined and painted (as shown) at our foundry and the complete units delivered on schedule.

RESULT:

TOTAL COST OF PART REDUCED 28.2%.

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design flexibility
Many small, intricately shaped parts that are now being fabricated separately by conventional methods can be economically Microcast into one stronger, ready-to-assemble component. Combining up to three small parts into one solid casting eliminates many costly machining and assembly operations and allows the engineer to design simpler components with a greater strength factor.
Design for fewer machine operations—design for better parts at less cost—design for longer part life and for functional improvements from the use of better metals and alloys . . . design with Microcast in mind!
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Pitts and D. G. Moore of the NBS Enameled Metals Laboratory, under the sponsorship of the National Advisory Committee for Aeronautics.

In the study, small sheets of the various coated and uncoated alloys were packed in an alloy box with a commercial carburizing compound. The box was then placed in a furnace and slowly heated to one of the three selected temperatures. After 4 hr at this temperature, the box was removed from the furnace and allowed to cool in air.

Of those studied, NBS ceramic coating A-19H proved most effective in preventing carbon absorption under all test conditions. However, the extreme severity of the test carburizing conditions would probably never be encountered in the practical operation of aircraft exhaust systems, and any of several coatings might well prove fully satisfactory in service. Service testing of coated exhaust parts is probably the only really valid method now available for establishing the relative merits of different ceramic coatings, according to the researchers.

Coatings for Molybdenum

The National Bureau of Standards recently conducted a study of protective coatings for molybdenum composed of chromium and frit (glass). Results indicate that such coatings greatly extend the useful life of molybdenum at high temperatures, giving better protection than either chromium or ceramic coatings alone. Various chromium-frit coatings were bonded to molybdenum specimens, then subjected to oxidation tests under tension in the range 1500 to 1800 F and to flame tests in the range 2000 to 3000 F. At temperatures of 1500 to 1800 F, the coated specimens lasted for 1000 to 3000 hr. At 2800 F, with no applied load, protection for as much as 7 hr was attained, enough to be valuable for some applications. The investigation was conducted by D. G. Moore and associates of the NBS Enameled Metals Laboratory, under the sponsorship of the National Advisory Committee for Aeronautics.

Ingot Iron at Low Temperatures

Insight into the effect of the strain-temperature history and strain aging of specimens of ingot iron on their tensile properties at low temperatures is provided by a study con-

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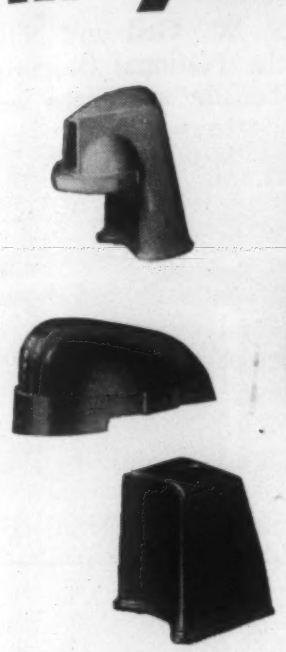

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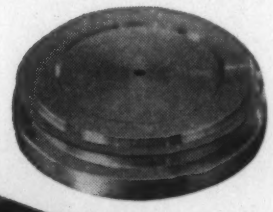

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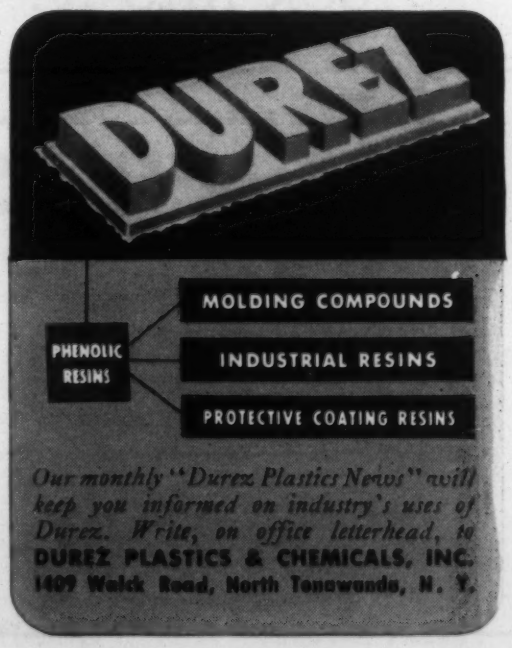
In Durez we have developed the well-known mechanical, electrical, and chemical properties of phenolics in many combinations of industrial importance. Your custom molder can help you to add more "hook" to your new products. Durez technical counsel is freely available, of course.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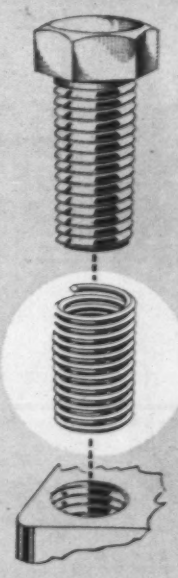

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News Digest

ducted by G. W. Geil and N. L. Carwile of the National Bureau of Standards. Tensile specimens were extended at selected temperatures, ranging from —196 to +100 C, to specified strain values and were subsequently extended to fracture in single-stage tests at the same temperatures. Much valuable information on the combined effect of previous strain and temperature was obtained.

On the basis of processing and previous heat treatment, the ingot iron samples studied could be classified as (1) annealed, (2) hot-rolled, (3) quenched and tempered, (4) normalized, or (5) cold-drawn.

The relative proportions of strain aging and strain hardening at the various temperatures for the five conditions of the ingot iron were determined on the basis of the known tendencies of these two types of work hardening to increase or decrease with temperature. Until now the general opinion has been that strain aging of ingot iron is insignificant at subzero temperatures. However, the data obtained by the Bureau shows that strain aging has a pronounced effect on the true stress-strain relationship of ingot iron specimens extended in tension at temperatures as low as —120 C.

The results of the study also shed new light on the so-called "rheotropic" brittleness of ingot iron. Some investigators have recently reported that a part of the brittleness in steels and other metals at low temperatures can be removed by cold work at temperatures above that of the transition range from ductile to brittle behavior. Such brittleness has been termed rheotropic, and a large part of the deficiency in ductility of annealed steels and some other metals at low temperatures has been reported to be rheotropic.

The data obtained show that the rheotropic brittleness of ingot iron depends upon the initial condition of the specimen. For example, it was found that cold working of hot rolled or normalized specimens by extension in tension at room temperature removed some of their brittleness at low temperatures, whereas similar cold working of annealed specimens increased their low temperature brittleness.

Nickel Properties

A study of the effect of tempera-

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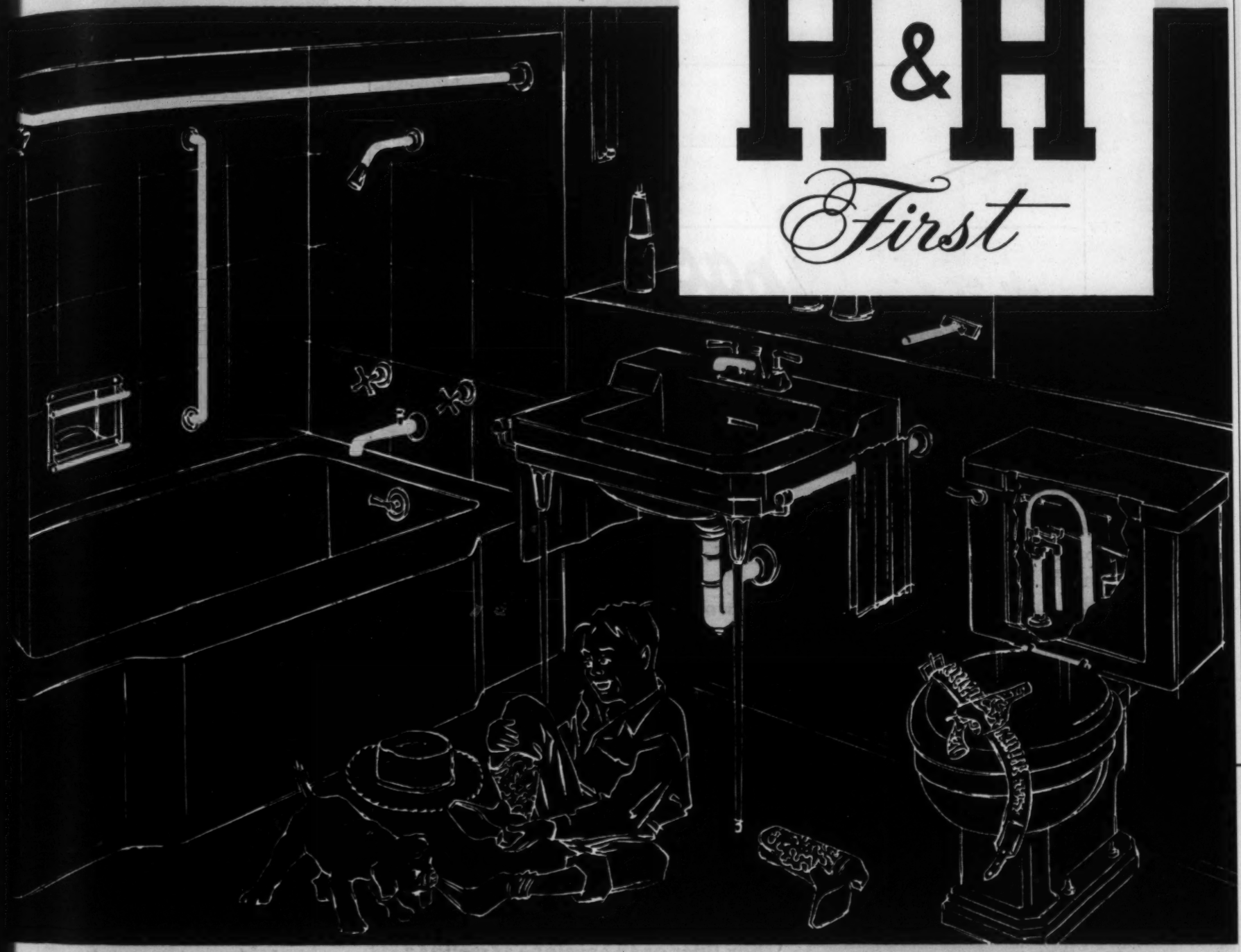

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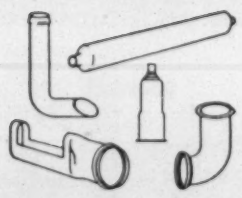

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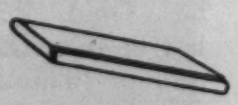
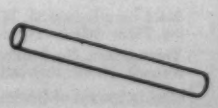
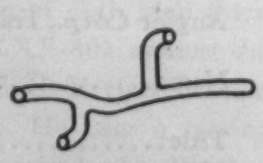


LOCKSEAM

COIL STRIP AND



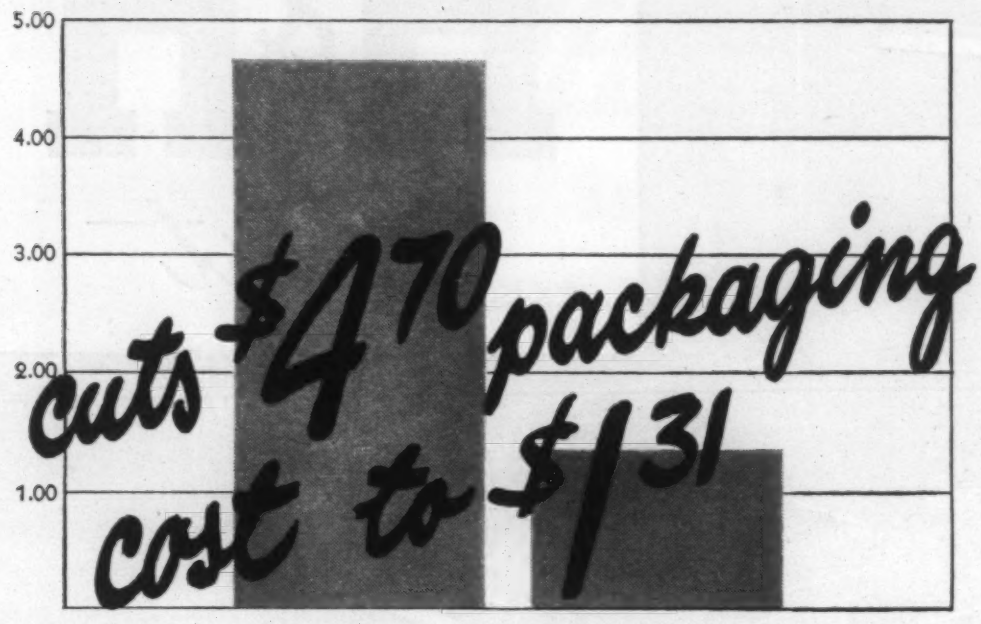
SEAMLESS TUBING



TUBULAR PARTS

Angier

Vapor from paper STOPS RUST of diesel locomotive parts



A leading locomotive firm used to dip diesel cylinder heads in an inflammable cleansing liquid. Then moisture had to be removed. This called for cranes and fire precautions. Dried with an air hose, heads were dipped into a varnish-like solution. To keep the sticky coating in place, waxed paper and heavy wooden boxes were "musts". Unpacking involved the same troubles in reverse. A couple of hours with a scrubbing brush came before the heads could be installed.

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- ☐ Other.

News Digest

ture on the tensile properties of high-purity nickel has also been completed by the National Bureau of Standards. Tensile tests were made at temperatures ranging from—320 to 1500 F on annealed specimens of nickel of 99.85% purity. The study was conducted by William D. Jenkins and Thomas G. Digges of the NBS Thermal Metallurgy Laboratory.

The NBS study shows that, in general, the metal's yield and tensile strength, and also the ductility at maximum load, tend to decrease with increase in temperature. The elongation at complete fracture attains a minimum at about 500 F. However, irregularities appear in the usual trends of some of the tensile properties in the temperature ranges of about 80 to 300 F and 500 to 700 F. Strain aging apparently occurs in the range 80 to 300 F, and Curie point behavior in the range 500 to 700 F, while recovery and recrystallization predominate at temperatures of 1200 to 1500 F.

Casting Institute Reports Technical Progress, Elects Officers

Meeting at Hot Springs, Va., in their 12th annual convention, members of the Alloy Casting Institute, a technical association of high alloy foundries, were given a complete picture of the accelerated progress being made in the vital field of high alloy castings materials and techniques.

Reporting to the assembled technical and operating executives of the nation's high alloy foundries, R. H. English, chief metallurgist, National Alloy Steel Div. of Blaw-Knox Co., Pittsburgh, Pa., and outgoing chairman of the Institute's Technical Research Committee, gave a detailed picture of intensive technical research being sponsored by the Institute at Ohio State University and at the Battelle Memorial Institute, Columbus, Ohio. Research at Ohio State has been carried out on the evaluation of titanium as a substitute for

(Continued on page 212)

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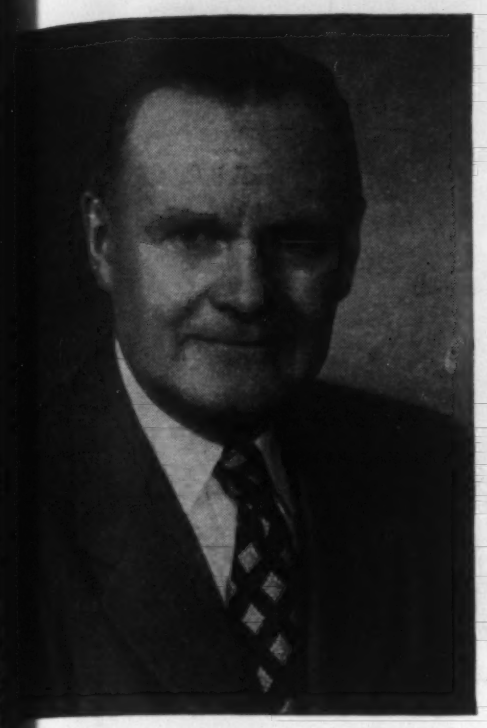
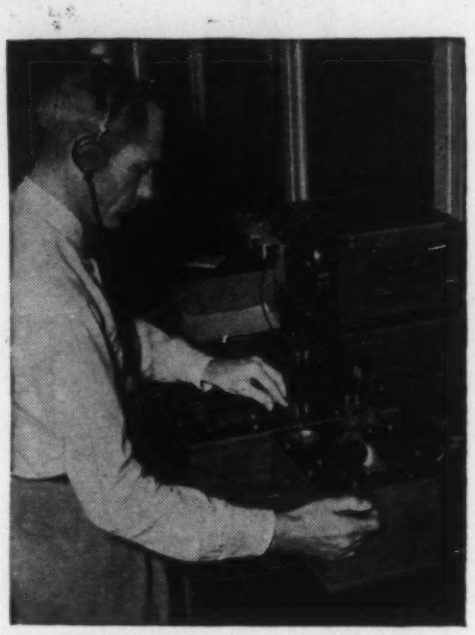


"National's quality control program starts with engineering research on the raw materials used and the development of material specifications. The next step is the preparation of process specifications for the various manufacturing operations. The final step is the testing of all products against specifications. We develop such specifications for all of our new products. For standard grades, we actively co-operate with A.S.T.M., N.E.M.A., and Government agencies in establishing standard values for essential properties. Rigid adherence to this program of quality control makes National products dependable—uniform."

Gerald H. Mains
Director of Research, Phenolite Div.
National Vulcanized Fibre Co.



George Holton, in charge of electrical testing laboratory, measuring dissipation or power factor at 1000 cycles of silicone Fiberglas sheet, Grade G-7-834, in a study of electrical characteristics of this new grade. The silicone Fiberglas material has heat resistance up to 250°C. and the lowest dissipation factor of any thermosetting laminate yet available.

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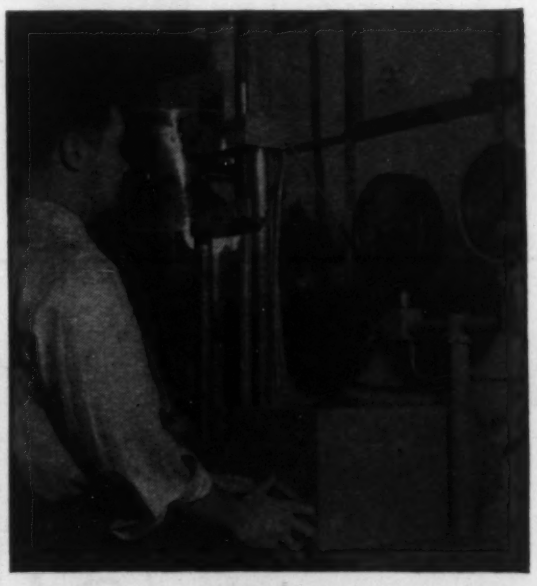
C. A. Mellinger, electrical engineer, testing dielectric breakdown of phenolic laminated sheet to meet requirements of N.E.M.A. standards for high dielectric strength. Test is made after sheet has been soaked in hot water (50°C) for 48 hours. This transformer makes possible tests up to 100 kilovolts.



Francis Corcoran tests the flexural strength of a piece of ⅛th inch thick Phenolite, Grade XXX-401, against the requirements of MIL-P Specification 3115B, type PBE. He uses a testing machine which employs hydraulic pressure to determine the number of pounds per square inch required to break the specimen supported as a beam.

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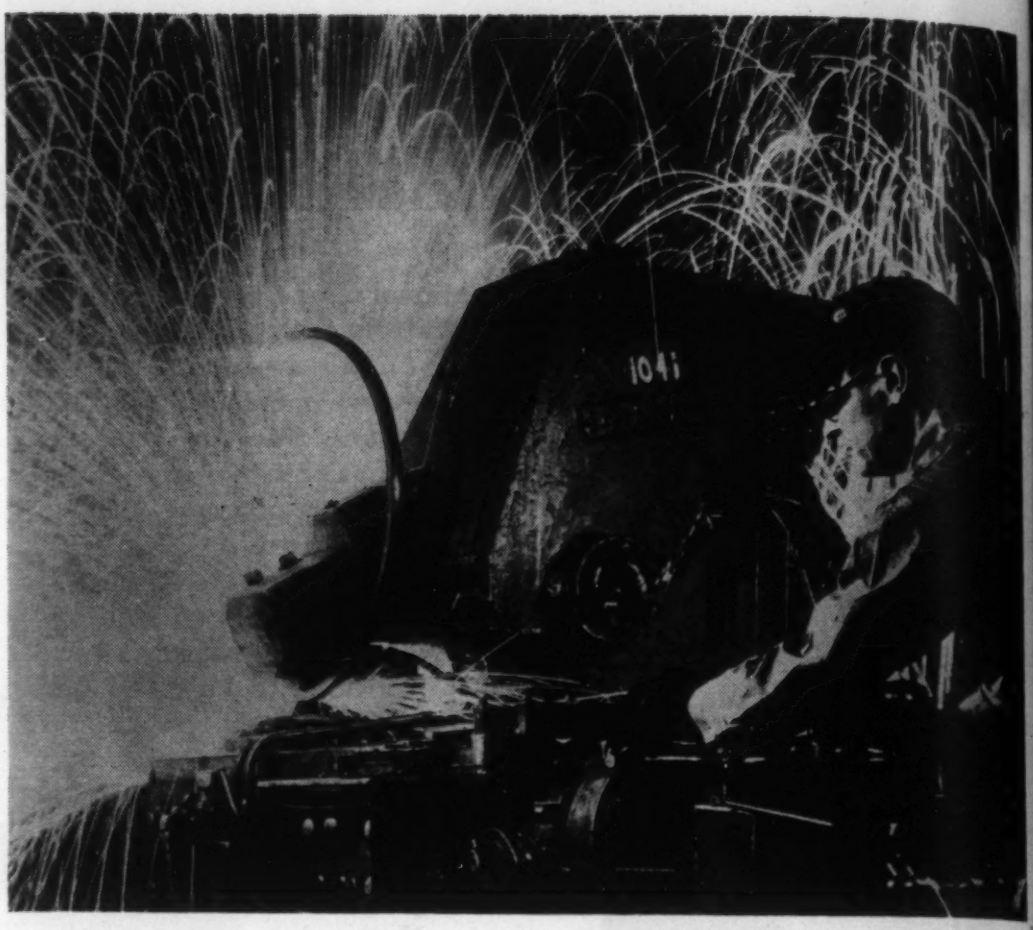


Flash butt welding a titanium ring at American Welding. Procedures resemble those for aluminum more closely than those for steel.

Flash Welding Titanium Alloys

by I. A. OEHLER, Director of Metallurgy and Research,

American Welding & Manufacturing Co.

Satisfactory welds in titanium alloys can be produced readily by modifications of the flash welding procedures used for aluminum.

● FLASH BUTT WELDING of titanium alloys is one of the lesser problems in the fabrication of these alloys. Satisfactory welds that closely approach parent metal properties are being regularly produced on conventional hydraulic machines.

Our initial work was done early in 1949 on samples of commercially pure ½-in. dia rod supplied to us by the Remington Arms Div. of du Pont. Excerpts from our report at that time follow:

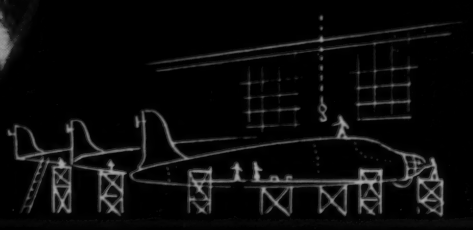
(1) No protective atmosphere was used; (2) Specimens tested to destruction had ductile fractures adjacent to the weld in the parent material; (3) The weld zone in the as-welded condition was acicular in structure; (4) Annealing at 1650 F refined this structure; (5) All welds appeared sound, with no inclusions or voids apparent in the microstructure.

Flashing travel of ¼ in., upset travel of 7/16 in., and final die opening of ¼ in. was used. The total welding cycle consumed 5 sec at a voltage setting of 2.9 v. Speed of upset was of particular importance, and fast speeds, comparable to those used for aluminum, were employed.

Following these initial tests, small production runs of RC70 bars were fabricated into rings and the joint flash welded. The weld burr was chipped off while hot. Cross sections

(Continued on page 208)

The Situation is Gripping ....



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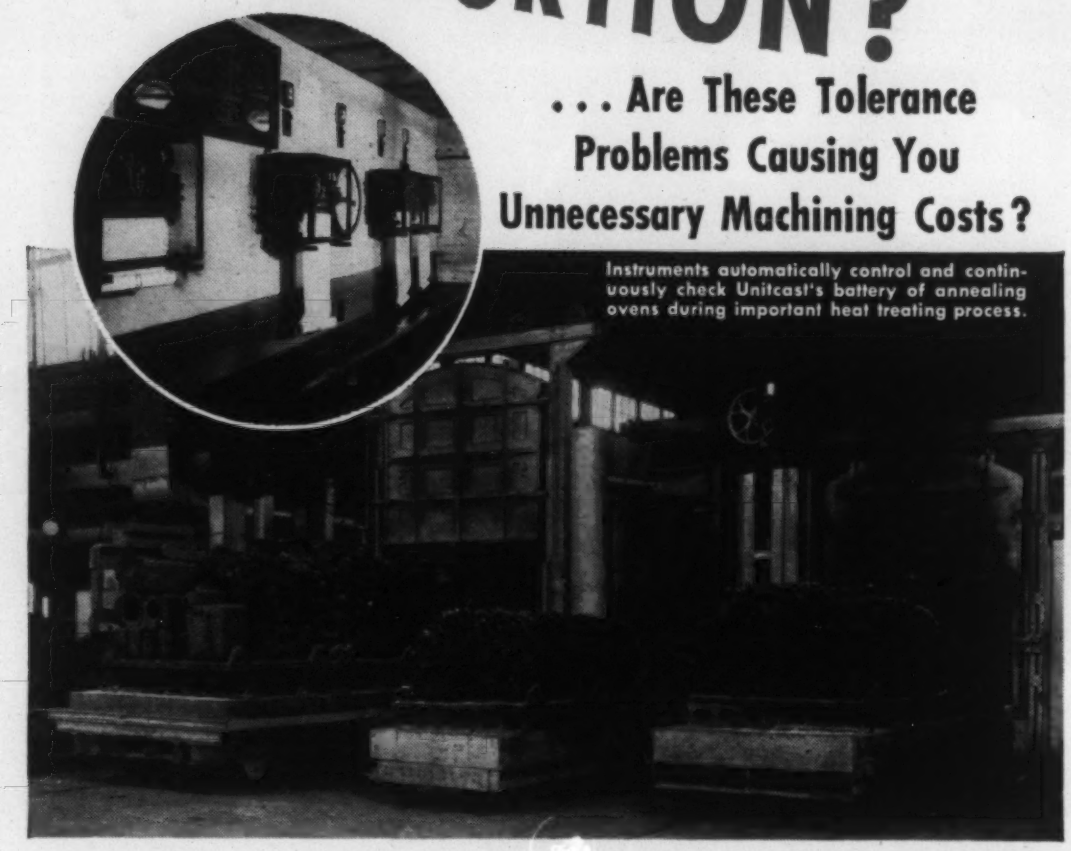

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Flash Welding . . . . .

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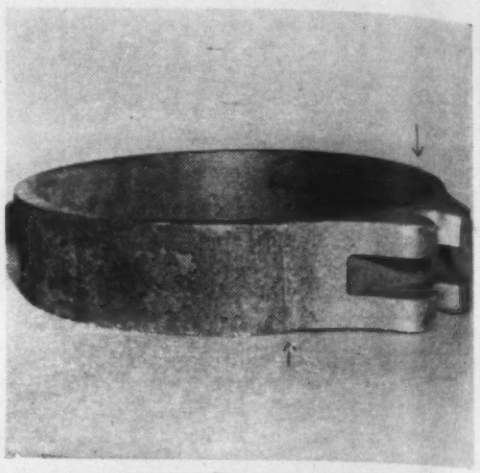

Titanium forging flash butt welded to an open ring. Arrows indicate the ends of the forging and the location of the welds.

up to 2 sq. in. have been welded, and it is believed that several times this area can be welded.

The introduction of the higher strength alloys such as RC-130B and TI-150A presented a problem not normally encountered in working with other ferrous and nonferrous materials. This was the apparent sensitivity of these materials to cracking in areas of surface or structural discontinuities. It was found that on bars which had surface defects removed by grinding just prior to shipment from the mill, cracking occurred when the bars were clamped in the welding machine. One lot, which had been checked for hardness at the mill, fractured through the Brinell impressions. If fracture did not occur at these points immediately upon clamping, it was noted that cracks appeared sometime after the weld was completed. The additional stresses set up by the thermal gradient during the welding cycle apparently are sufficient to cause failure. When bars were annealed at the mill after surface preparation, no trouble was encountered. In our own processing, it was found that a rough chip or grind mark could give rise to cracks, but cracking could be avoided by getting the rings into a furnace at 1300 F immediately after welding.

A typical weld cycle for 2 by 5/16-in. bars of RC-130B flash welded into a ring consumes 8 sec with the voltage (open circuit) at 6.2. Flashing travel was 3/4 in., upset travel 3/8 in., and final die opening 1/2 in. That cycle produced welds of 152,000 psi tensile strength, 146,500 psi yield strength, and 15% elongation in 2 in. with a reduction in area of 46%.

Occasionally welds of good

(Continued on page 210)

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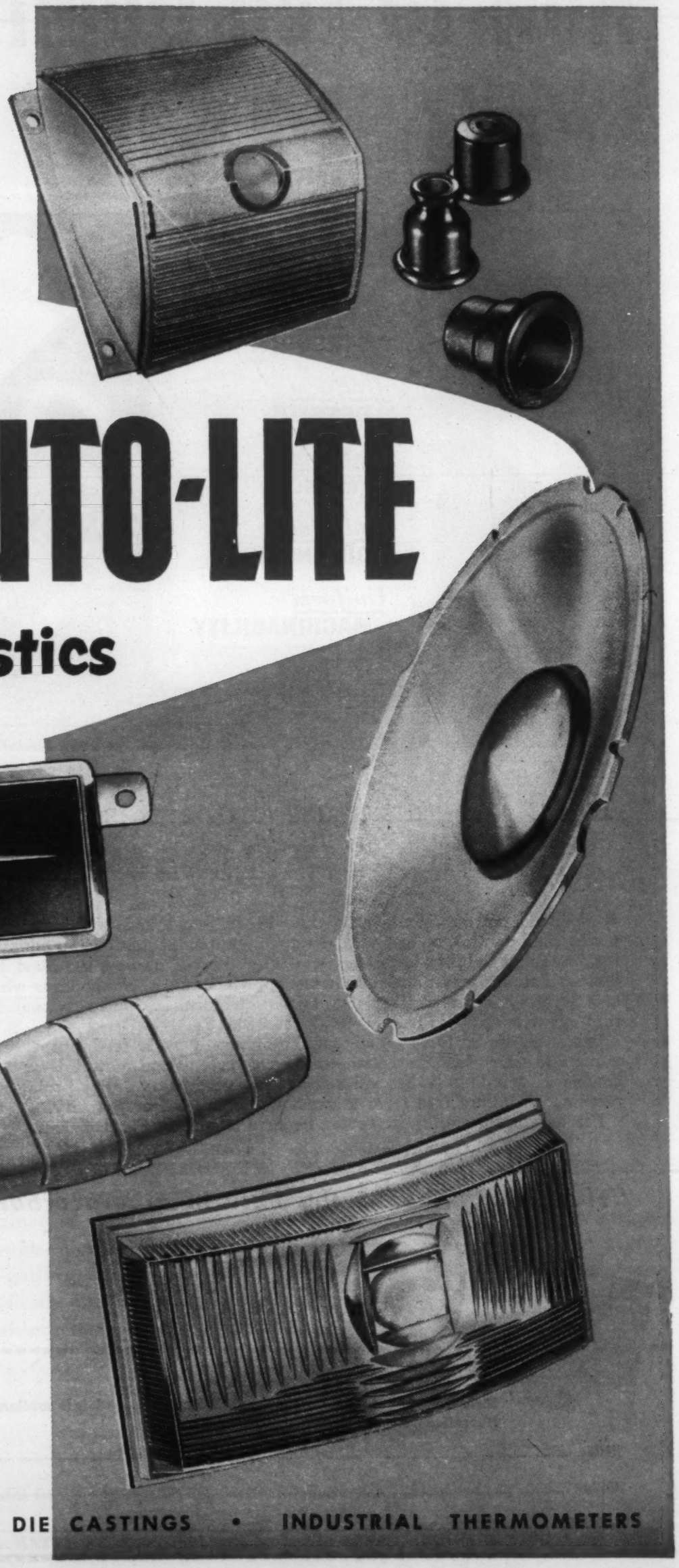

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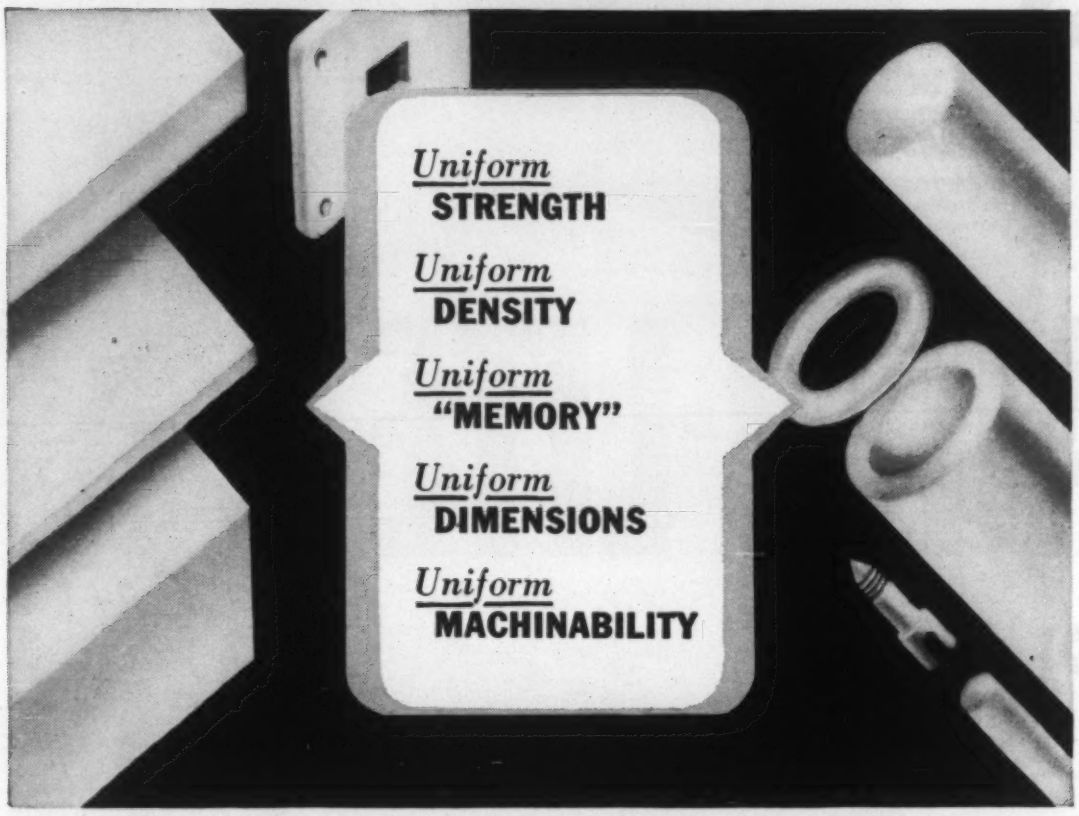

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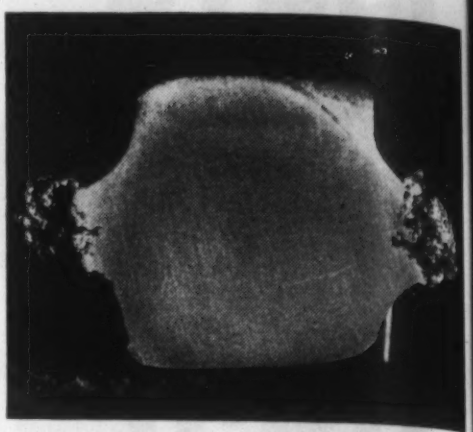

Macrograph of the weld section of a ½ in. titanium bar showing the weld area and upset, or flash, at the sides.

strength exhibited very low ductility —elongations of 1 to 7%. Investigations in our customer's laboratory, as well as in our own, showed this to be associated with a banded structural condition in the bars. Additional welds made in the same banded bar always showed low values. A similar condition is encountered on heavily banded dirty steels that are flash welded. The upset portion of the welding cycle turns the fibers at the weld outward so they lie transverse to the bar axis and the inclusions present in the material act as notches which produce brittle failures. In the titanium alloys, a banded structure without any apparent inclusions as such, is sufficient to produce failure. This condition is now well known to the alloy manufacturers and so should not be encountered in the future on flash welding applications.

Titanium alloys have been flash welded to aluminum alloys and to carbon steels. This work was carried on only as a curiosity, with no present practical applications in mind. On such joints, failure occurs outside the weld when tested in tension or bending.

In summary, flash welding of titanium alloys can be readily accomplished provided:

(1) Material is of good quality and uniform structure. (2) Techniques similar to those used for aluminum are employed. (3) Welded parts are annealed or otherwise furnace treated immediately after welding.

Adapted from a paper presented to the Titanium Fabrication Conference, Minerals and Metals Advisory Board, National Academy of Sciences, National Research Council, Cleveland, Ohio, June 19, 1952.

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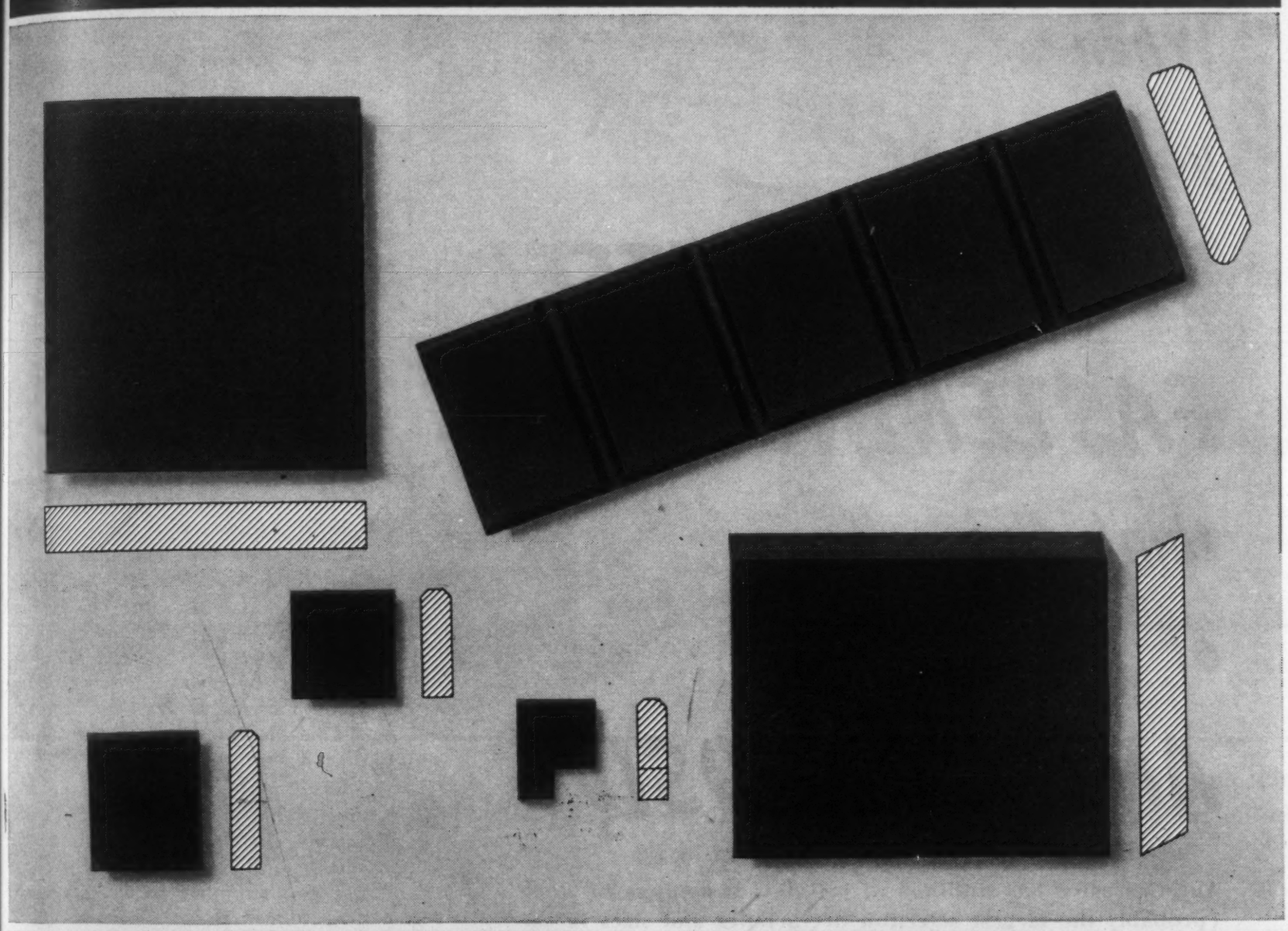

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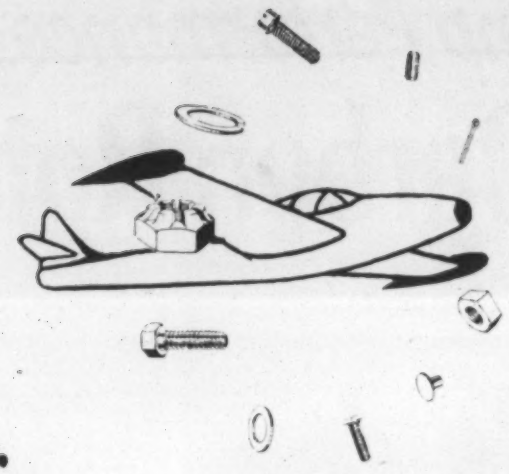

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News Digest

continued from page 204

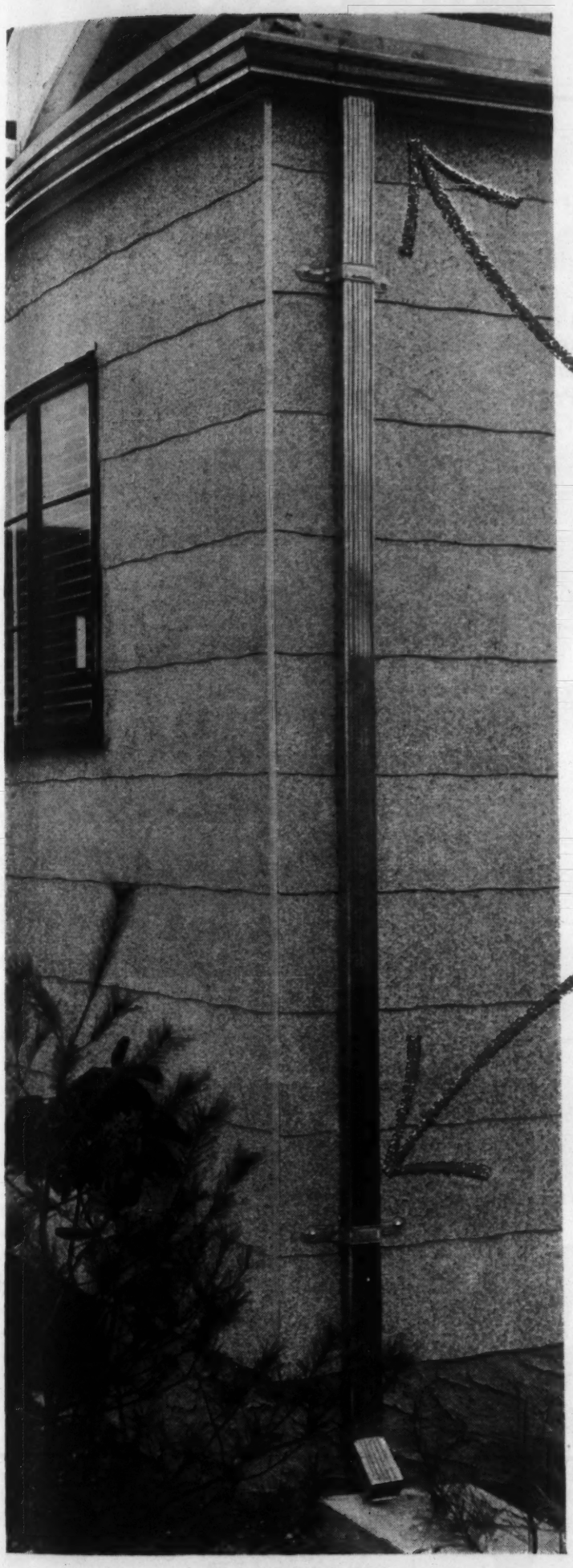
columbium in the cast stainless steel alloys. A final report on this work will be presented to the technical committee of the Institute in September.

The research at Battelle, according to Mr. English, was concentrated on high temperature work, with the majority of the effort being devoted to a study of the 20 chromium, 9% nickel composition type for elevated temperature service (recently announced by the Institute). Maximum and minimum amounts of chromium were investigated, as they affect thermal fatigue properties and strength at elevated temperatures. Other high temperature programs scheduled for the following year include a study of the correlation of thermal fatigue and stress rupture properties of the 35 nickel, 15% alloy composition range. Mr. English also announced the completion of a study of the effect of composition on resistance of high alloys to corrosion by neutral heat treating salts. The results of this program will be presented before the annual Metal Congress in October, 1952.

Results of research at still another technical institution, the Massachusetts Institute of Technology, were reported on behalf of the Shop Practice Committee by W. T. Bryan of the Duriron Co., Dayton, Ohio. This research had been devoted to the improvement of surfaces on high alloy castings. Recommended procedures for foundry control were outlined by Mr. Bryan.

In the election of Institute officers to serve for the coming year, Harvey T. Harrison, executive vice president, The Duraloy Co., Scottdale, Pa., was reelected as president. G. A. Baker, vice president, the Duriron Co., Dayton, Ohio, was elected as the new vice president of the Alloy Casting Institute. Two new directors were elected for the terms ending 1954; these were: C. M. Carmichael, vice-president, Stainless Steel & Alloys Div., Shawinigan Chemicals Limited, Montreal, Quebec, Canada, and M. N. Ornitz, vice president, National Alloy Steel Div., Blaw-Knox Co., Pittsburgh. E. A. Schoefer, executive secretary of the Institute, was re-elected.

New officers of the important



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News Digest

Technical Research and Shop Practice Committees were also announced: chairman of the Technical Research Committee is now N. A. Matthews, of the metallurgical laboratories of the American Brake Shoe Co., Rahway, N. J.; and the new chairman of the Shop Practice Committee is R. O'Conner, Cooper Alloy Foundry, Hillside, N. J.

Research Reports Available to Public

The Office of Technical Services, U. S. Dept. of Commerce, has recently announced a number of research reports now available to the public. The reports and where they can be obtained follow:

"Development of Protective Coatings for the Aluminum Combat Canister Mll," U. S. Chemical Corps. 30 pp. Available from Library of Congress, Photoduplication Section, Washington 25, D. C. Microfilm $2.00, Photostat, $3.75. Describes representative types of organic coatings used for the protection of metals against the corrosive action of chemical agents. Report PB 106607.

"Bright Zinc Coatings," British Intelligence Objectives Sub-Committee, 5 pp. Available from Library of Congress, Photoduplication Section, Washington 25, D. C. Microfilm $1.25, Photostat $1.25. PB 106767.

"Study of Investments for Precision Casting Process," U. S. Air Material Command, 12 pp. Available from Library of Congress, Photoduplication Section, Washington 25, D. C. Microfilm $1.75, Photostat $2.50. An investigation was conducted to study the feasibility of using less critical materials for the investments now used in the precision casting process. Investments were formulated from less critical materials. Several of these compositions proved to be satisfactory as substitutes for the investment now used in the precision casting process.

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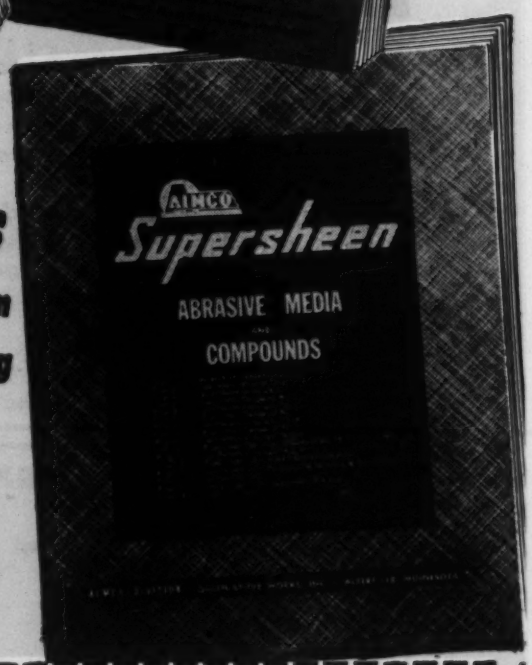

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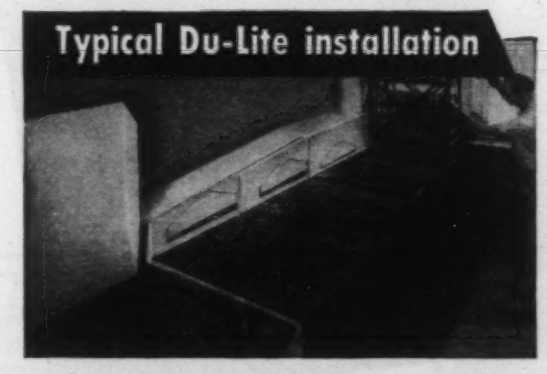

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Control of Materials, Tools, Machines, Volume 2." Curtiss-Wright Corp. 98 pp. Free of charge, Curtiss-Wright Corp., Woodridge, N. J. This book concentrates on the effect of the microstructures of plain-carbon, alloy and stainless steels on tool life. Cutting characteristics are shown to be similar for like microstructure of several steels. Correlation between cutting temperature and tool life is shown. Machining properties in terms of cutting are also given. One of a series of reports prepared as part of machinability research program sponsored by U. S. Air Force. PB 106657.

"Symposia on Materials and Design for Light-Weight Construction: The Magnesium Symposium." Sponsored by Engineer Research & Development Laboratories and the Magnesium Association, 62 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. Mimeograph: $2.00. Development and present status of the magnesium industry; physical and mechanical properties and specifications for magnesium alloys; structural design and design for extrusions; design for magnesium castings and forgings; corrosion resistance and protective systems or coatings for magnesium alloys, shop practice, forming, machining, and joining. Report PB 106332.

"Effect of High Temperature Steam on a Nickel-Chromium-Iron Alloy," Missouri Engineering Experiment Station, Columbia, Mo., 50 pp. Available from Engineering Experiment Station, University of Missouri, Columbia, Mo. Describes the effect of high temperature steam attack (2200 F) on a nickel-chromium-iron alloy known as Chromel-C. At the surface, high temperature steam attack results in the formation of a thin, hard film of chromium oxide which has special properties in the field of steam generation. Within the interior, high temperature steam attack leads to chemical reactions with metallic oxides, carbides, etc. These reactions can weaken and open grain boundaries, cause local melting and recrystallization, induce high thermal stress, generate gas at high pressure, and even extrude plastic interior metal through the surface crust. Report PB 106759.

"Large Forgings in Germany." Lecture Delivered at Light Metals

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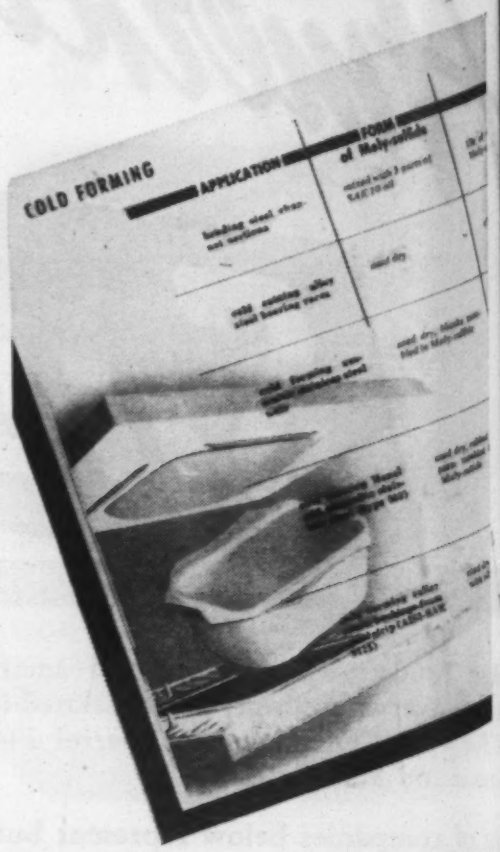

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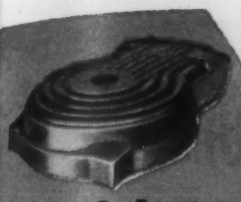
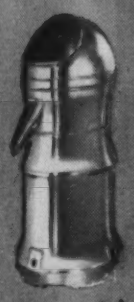
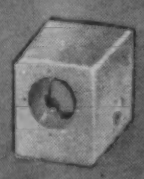
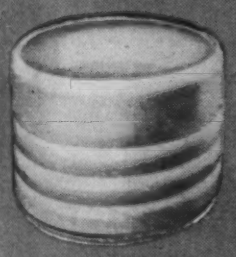

Base For Power Lawn Mower

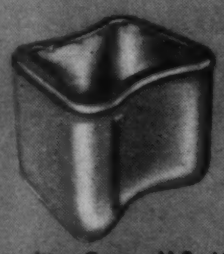

Commercial Fruit Juicer

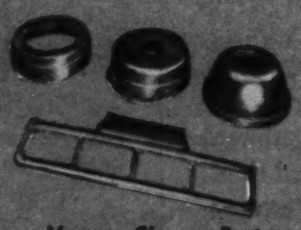

Solenoid Cover U.S. Navy


Washing Machine Tub

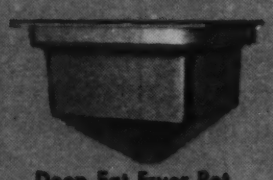
Fuel Tank

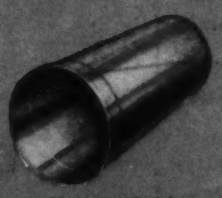
Gas and Water Cans U.S. Quartermaster

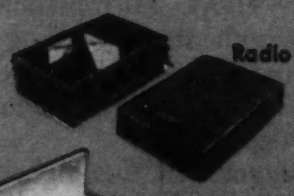

Transmitter Case—U.S. Air Force

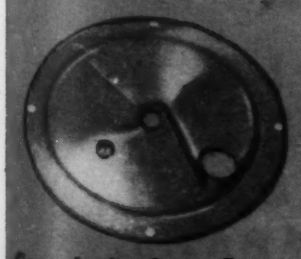

Vacuum Cleaner Parts

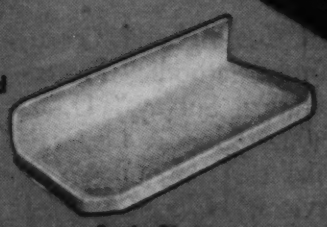
Aerial Delivery Container U.S. Air Force


Deep Fat Fryer Pot


Longhorn Cheese Mold


Radio Case—U.S. Signal Corps


Cover for Ice Cream Freezing Equipment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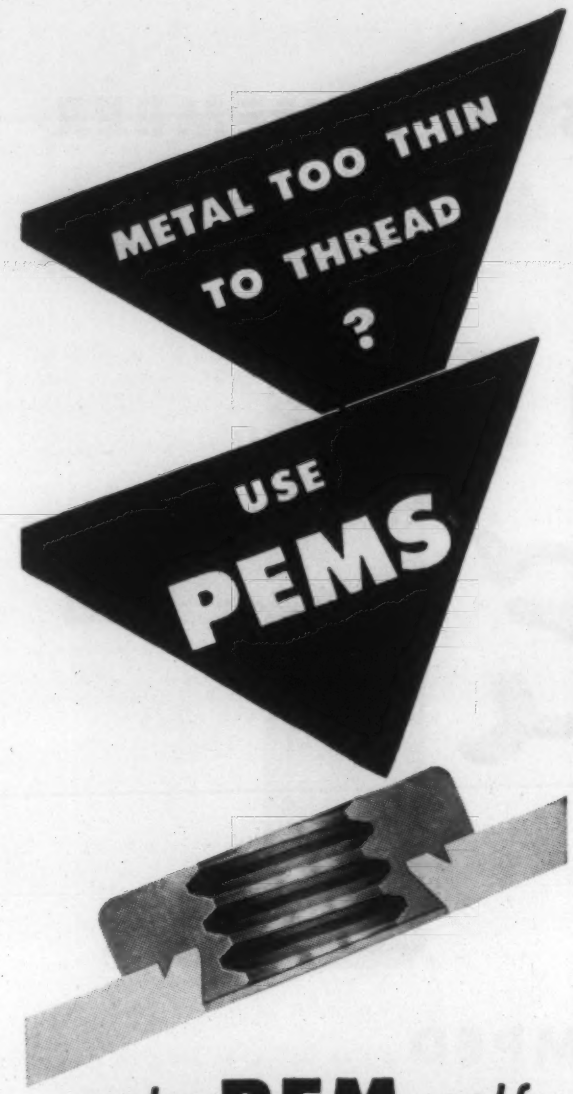

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News Digest

Forging Symposium, Wyman-Gordon Co., Worcester, Mass., by Hubert Altwicker. U. S. Air Material Command, 21 pp. Available from Library of Congress, Photoduplication Section, Washington 25, D. C., Microfilm $2.00, Photostat $3.75. Discusses physical properties and fabrication of steel forgings, aluminum-copper forgings, aluminum- magnesium-zinc forgings and magnesium alloy forgings. Report PB 106984.

"Investment Precision Casting." U. S. Office of Technical Services. 15 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C., Mimeograph: 25¢. Treats: Lost-wax process; cobalt alloys-casting; precision casting. Report PB 111001.

"Light Metal Castings, Miscellaneous Papers: Germany." Reichsluftfahrtministerium 52 frames (text in German). Available from Library of Congress, Photoduplication Section, Washington 25, D. C. Microfilm $9.00, Enlargement Print $70.00. Treats light metals casting. English abstract included. Report PB 106835.

"Titanium-Columbium, Titanium-Molybdenum and Titanium-Silicon Phase Diagrams," Armour Research Foundation, Chicago, Ill., 128 pp. Available from Library of Congress, Photoduplication Section, Washington 25, D. C. Microfilm $5.00, Photostat $16.50. The titanium-columbium, titanium-molybdenum and titanium-silicon systems were determined using alloys cast in consumable and nonconsumable electrode inert atmosphere arc melting furnaces. Working and annealing treatments were carried out under conditions that minimized contamination of the high purity alloys. Micrographic analysis after isothermal annealing followed by quenching was the chief method used for phase identification. Report PB 106954.

"Magnesium Coating and Corrosion (Including Cathodic Protection). A Literature Survey." U. S. Office of the Quartermaster General, 39 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. Mimeograph: $1.00. This literature survey has been prepared to furnish Quartermaster technicians with existing methods for evaluating the performance of magnesium coatings on base metals and to present information dealing with corrosive influences

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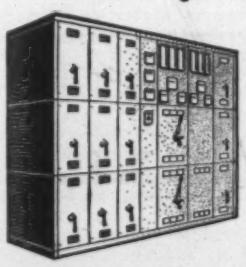

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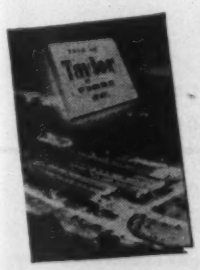

This comprehensive 24-page booklet literally brings the entire Taylor Organization to your fingertips . . . tells in words and pictures how the many Taylor Laminated Plastics are made . . . shows you how you can use these basic materials to make your product better, at lower cost. Write today for a copy of Booklet *MM9.*

They are versatile phenol, melamine and silicone laminates whose unsurpassed electrical characteristics and easy machineability make them real time-savers on the production line.

Availability of these materials in many forms, such as sheets, tubes, rods, strips and coils, makes them easily adaptable to numerous production operations.

And when production processes call for laminated parts fabricated to specifications, Taylor's Fabricating Service turns out precision-made parts having all the physical, mechanical, electrical and chemical characteristics required.

So if you're a production manager looking for ways to make products or parts better, more efficiently and at lower cost, investigate Taylor Laminated Plastics today! Write for complete data. Ask, too, about Taylor Vulcanized Fibre and Taylor Insulation.

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TAYLOR FIBRE CO.

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PHENOL • SILICONE • MELAMINE LAMINATES • FABRICATED PARTS

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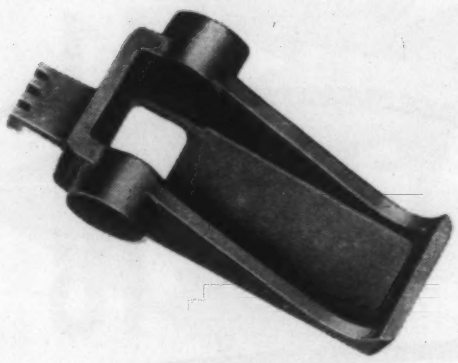

Once again Precision Investment Casting proves its value and practicability.

The illustrated part was designed for lightness, strength, and for a better functional design. It is cast in SAE-1020 steel so that it may be heat treated.

Had any other method of manufacture been used many machine operations would have been encountered that would have increased the cost considerably.

Engineers and Designers in all types of products are finding a proven and trusted servant in Precision Investment Casting.

You should check with our engineers for help in cutting costs and machining time on your parts.

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News Digest

on these coatings in order that new products may be developed to meet new, more stringent acceptance tests. The scope of the survey is limited to the years 1946-1951. Report PB 106654.

CORRECTION

On page 180 of the July 1952 issue of MATERIALS & METHODS, a report was made on a paper presented before the general meeting of the American Iron and Steel Institute by Dr. E. C. Bain. Dr. Bain was referred to as vice president of the United States Rubber Co. Dr. Bain is actually vice president of the United States Steel Co.

News of Engineers

International Telephone and Telegraph Corp. has announced the election of *Patrick J. McGann* to the office of vice president.

Thomas H. Risk, formerly research engineer for the Ethyl Corp., has been named a vice president of the R. M. Hollingshead Corp.

Marion Electrical Instrument Co. has announced the appointment of *John D McLellan* as plant manager. Mr. McLellan, formerly vice president and general manager of J. H. Bunnell & Co., will take charge of manufacturing operations.

Dr. *Alfred Marzocchi* has been appointed manager of the Textile Chemistry Section of the Fiberglas Textile Products Laboratory, Owens-Corning Fiberglas Corp.

The retirement of *A. W. Payne* as chairman of the board of directors of Crane Packing Co., after more than 30 years of active participation, has been announced. *Frank E. Payne*, formerly president, was elected chairman of the board, and *Karl V. Rohlen* has been made president.

Dr. *Frank A. Crossley*, head of the Dept. of Foundry Engineering at Ten-

ATTENTION:

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60 Wire as an Engineering Material
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64 Mechanical Finishing of Metals—for Decorative Purposes
65 Welding Electrodes and Rods—for Ferrous & Nonferrous Metals
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68 Glass as an Engineering Material
69 Cleaning and Finishing Stainless Steels
70 Compression Molded Plastic Parts
71 Wrought Aluminum Alloys
72 How to Overcome Materials Shortages in Product Design and Manufacture
73 Die Castings
74 Wrought Phosphor Bronzes
75 Salt Baths for Metal Treating
76 Cold-Headed Parts
77 Titanium, Zirconium, Molybdenum, Etc. as Engineering Materials
79 Plastics as Alternate Materials
80 How to Select Brazing & Soldering Materials
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. . . That's the term for these outsize valves produced by PHOENIX-SPUN for a Jet Turbine Testing Laboratory. Fabricated from 16-gauge stainless steel, each unit consists of a spun nose welded to a conical section, with the entire outer skin welded to fabricated steel ribs.

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Metal Spinning Division
PHOENIX PRODUCTS CO.
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SEE OUR CATALOG IN SWEET'S
For Product Designers

News Digest

nessee A. & I. University, has been appointed associate metallurgist by Armour Research Foundation of Illinois Institute of Technology. *Verne Pulsifer,* chief metallurgist for Olin Industries, has been appointed a supervisor in the Metals Dept. at the Foundation.

The Westinghouse Order of Merit, highest company award for distinguished service, was presented to the following nine executives and engineers: *Fred R. Davis,* of Lima, Ohio, manufacturing equipment design engineer, Small Motor Div.; *Frank W. Godsey, Jr.,* Baltimore, manager of the Electronics, X-Ray and Air-Arm Divs.; *Robert L. Jeans,* New York, manager, Projects Div., Westinghouse Electric International Co.; *Lee A. Kilgore,* East Pittsburgh, assistant manager, alternating current generator engineering, Transportation and Generator Div.; *John D. Miner, Jr.,* Lima, manager of aviation engineering, Small Motor Div.; *Otis Rae,* Atlanta, Southeastern District manager; *John B. Seastone,* E. Pittsburgh, manager, materials engineering; *Philip C. Smith,* E. Pittsburgh, assistant to manager, Transportation and Generator Div.; *Carroll E. Valentine,* E. Pittsburgh, manager, design section, generator voltage regulators. Other awards received by company officials have also been announced: Dr. *John W. Marden,* Lamp Div. research scientist, recently received the highest civilian award given by the Army, The Certificate of Appreciation, made in recognition of his development of an alloy for lining barrels of automatic weapons. *William R. Harding, Jr.,* an engineer in the Buffalo plant, has been awarded the Benjamin Garver Lamme Graduate Scholarship for 1952-53. The appointment of *S. C. Leyland* as manager of engineering, Meter Div., has also been announced by the company.

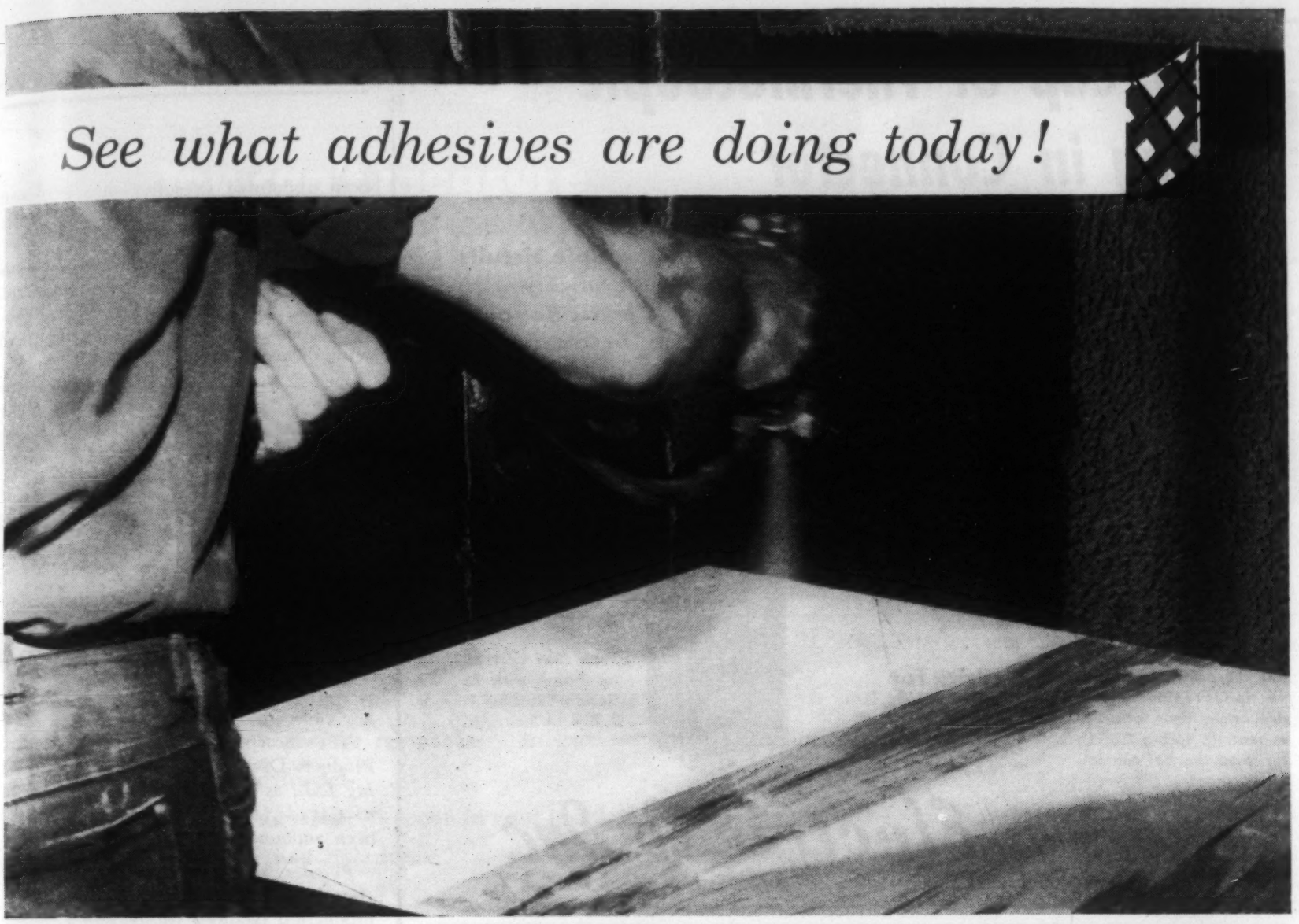
The TOCCO Div., Ohio Crankshaft Co., has announced the opening of a West Coast office under the management of *Harlan A. Messner.* The office is located at 3349 Union Pacific Ave., Los Angeles 23.

Thomas J. Menzel has been appointed plating chemist by Hanson-Van Winkle-Munning Co.

C. J. Berini has been named division manager, Wayne Div., Gar Wood Industries, Inc.

The following new officers have been elected by United Engineering and Foundry Co. *K. C. Gardner, Sr.* has been named chairman of the board and chief executive officer to fill the vacancy created by the recent death of *F. C. Biggert, Jr.; Geoffrey G. Beard,* formerly executive vice president, was elected president and general manager; *Maurice P. Sieger* has been named vice president and senior engineer of the company.

J. D. Swain and *E. H. Mangan* have



Turning out TV cabinets 100% faster!

For all the miracles of science and engineering wrapped up in a television chassis, the cabinet which holds them was still a hand-made item—until the Crosley Division of the Avco Manufacturing Company found a better method . . . with the help of 3M adhesives.

At Crosley veneered plywood panels are bonded to a welded steel frame with adhesives*. By making cabinets in this fashion, costly hand work is eliminated and cabinet making put on a production line basis.

When Crosley first conceived this technique they turned to 3M for *adhesives engineering*. Working together, job-engineered adhesives and required production methods were developed. The result is a cabinet of unsurpassed beauty . . . strength greater than in hand-made cabinets . . . lower costs . . . and a production greatly increased!

3M adhesives are the modern solution to many types of fastening or bonding problems, often bringing important savings in cost and a better product. Along with superior adhesives, 3M can also provide you with the engineering services so important to a successful application.

See what adhesives can do for you . . .
Call your nearest 3M office and have a 3M adhesives engineer give you technical help on your problem. Or write 3M, Dept. 69, in Detroit for a fact-filled 32-page booklet on 3M's engineered adhesives, coatings and sealers.

*U. S. Patent 2562257

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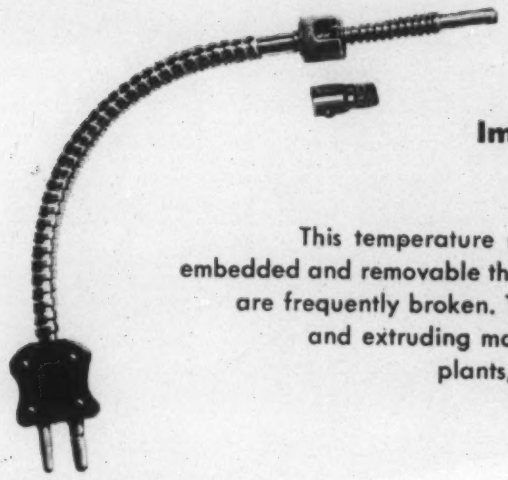
Twist Cap of Thermocouple & Plug in Connector

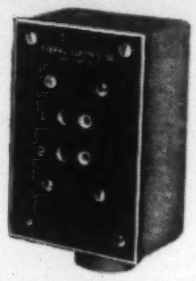


Thermocouple circuits completed that quickly with Thermo Electric Bayonet Immersion Contact Thermocouples and Connector Panels

This temperature measuring system is principally used when embedded and removable thermocouples are required and when circuits are frequently broken. Typical applications include plastic molding and extruding machines, permanent molding machines, pilot plants, test stands, engine cylinders, bearings, etc.

Type 202D Iron Constantan Bayonet Immersion Contact Thermocouple has silver tip for rapid response, drill angle taper for proper seating, spring tension for good thermal contact.

Write for Catalog G



Type JBW Connector Panel with FS Conduit Box for 1, 2, 3, 4, or 5 circuits.

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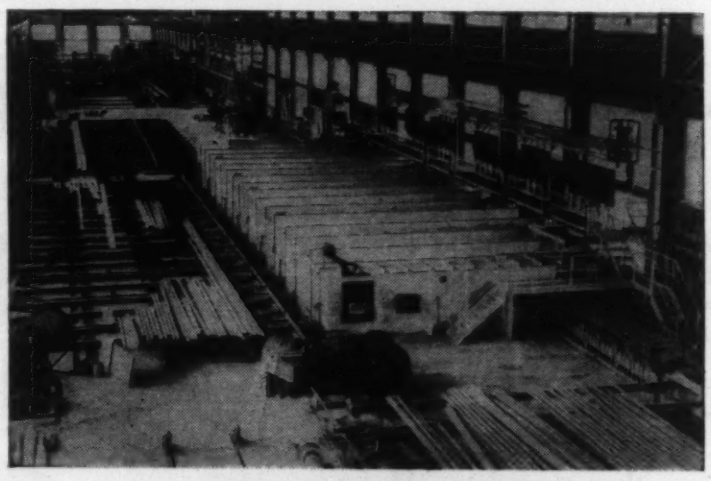

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● Our wide experience in the processing of aluminum, magnesium and other non-ferrous and ferrous products can save you time and money. We build continuous and batch type furnaces,— gas fired, oil fired or electric . . . whichever is best for your particular requirement — furnished complete with all necessary charging, discharging, quenching, special atmosphere and special handling facilities. For long, efficient, trouble-free service, let EF engineers work with you on your next furnace problem.

Gas-Fired, Oil-Fired EF and Electric Furnaces
for any Process, Product or Production
THE ELECTRIC FURNACE CO.
WILSON ST. at PENNA. R. R. Salem - Ohio

News Digest

been appointed executive vice presidents of Electro Metallurgical Co., a division of Union Carbide and Carbon Corp.

The death of *Ingwald M. Larson*, secretary, Claud S. Gordon Co., has been announced. Mr. Larson had been associated with the company for 25 years.

The death of *R. C. Brower*, secretary-treasurer and director of Timken Roller Bearing Co., has been announced by the company.

News of Companies

The incorporation of the Commercial Products Div., *Eldorado Mining & Refining Ltd.*, as a division of *Atomic Energy of Canada, Ltd.*, a new Crown Co., has been announced.

Powder Metal Products Corp. of America has announced availability of production facilities for precision castings made by the new shell molding process. The line will be marketed under the name Die Mold Castings.

Steiner-Ives Co. has begun construction of a new plant at Union, N. J.

A new jet engine laboratory, believed to represent the most comprehensive engine analog work ever attempted by a control manufacturer, is being established by the *Aeronautical Div., Minneapolis-Honeywell Regulator Co.*

In its second major enlarging move in 12 months, *California Reinforced Plastics Co.* has announced purchase of a 20,000 sq ft building at 951 61st St., Oakland, Calif. The new move is expected to greatly increase production capacity of honeycomb to meet the growing demand from aircraft companies and fabricators.

Tyer Rubber Co. has announced plans for a new factory building which will be located adjacent to the company's present plant buildings on Railroad St., Andover, Mass.

Galvanic Products Corp. has announced completion of its new plant at Valley Stream, N. Y. The new building contains all of the equipment and facilities—chemical, mechanical and electrical—required for manufacturing Selenium rectifiers, complete rectifier equipment and allied electronic components.

Penn Metal Co., Inc. has announced the opening of new offices at 1025 Connecticut Ave., N. W., Washington, D. C.

The *H. W. North Co.* has moved its headquarters and all divisions to the 3-

You can't measure surface temperatures *accurately* with a toy!

Ever look inside a shiny mechanical toy? Inside—where the "Work" is done— you don't find the quality that says craftsmanship, performance and durability.

Apply the same test of quality when you choose a surface temperature instrument . . . look inside!

Hold an Alnor Pyrocon in your hand . . . feel the fine balance . . . notice the all-metallic case and shatter-proof glass.

These things speak of quality design and attention to detail. *BUT* that isn't enough to judge performance of a Pyrocon—or any instrument. Look closely at a Pyrocon!

look at the yoke . . . where the thermocouples are attached. Notice that neither plate connection is grounded. Also, those plates are of chromel and constantan alloy . . . a feature developed by Alnor.

look at the arm* . . . that is electrically inert, serving only a mechanical function so that it cannot influence accuracy. See how the rigid arm can be rotated to *any* position and still leave the scale face in a readable position.

look at the movement . . . and see why we guarantee accuracy of ±2% under *all* ambient temperatures and all combinations of arms and couples. High circuit resistance and low current demands produce a movement of extreme sensitivity and high, constant accuracy.

look at the magnet . . . Alnico, of course. Its large size creates high flux density that directly affects sensitivity. Notice, too, the machined pole pieces that also increase accuracy throughout the scale range.

look at the base . . . a heavy brass piece that supports the entire movement assuring permanent, rigid alignment. This sturdy foundation means long-lived accuracy and electrical stability—even in severe service.

. . . And you'll see why the Alnor Pyrocon is the recognized leader in the field of surface temperature indication. These Alnor features are the result of years of manufacturing experience . . . pioneering design and continuing research.

*** Also available with flexible arm. Complete selection of thermocouples. Scale ranges 0-300°F., to 0-2000°F. or Centigrade equivalents.**

Alnor

When you measure Surface Temperatures you need precision . . . craftsmanship . . . durability. You need an Alnor Pyrocon.

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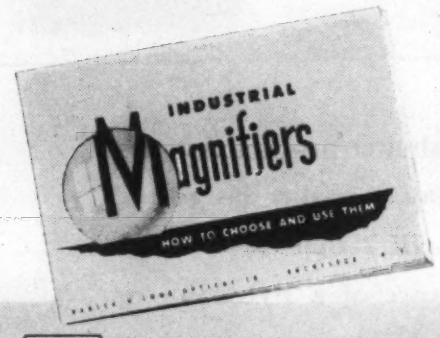
Cut waste, get faster, surer inspection by fitting the magnifier to the job. Get top-performance magnifiers made by Bausch & Lomb, recognized world leader in precision optical goods. Operators see more clearly; accurate decisions are made easier, costs are reduced.

NEW 5X
HASTINGS TRIPLET

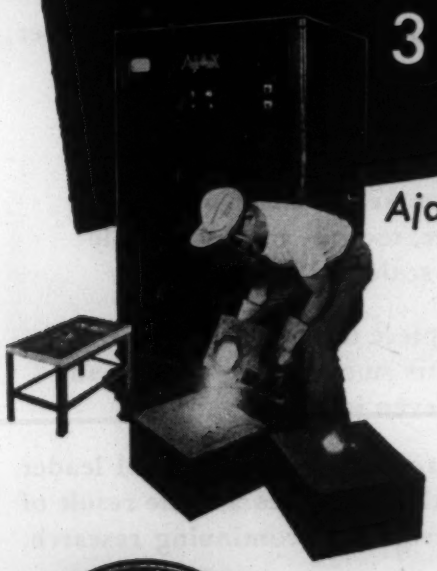
Maximum correction combined with moderate power to provide exceptionally wide field, long working distance and superb definition. Available with new Hand Illuminator.



WRITE for new handbook and catalog, "Industrial Magnifiers—How to Choose and Use Them." Bausch & Lomb Optical Company, 50309 Bausch St., Rochester 2, N. Y.

B&L BAUSCH & LOMB *Magnifiers*

FOR MELTING ALL ALLOYS 3 TO 60 POUNDS



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A complete, easily installed induction melting furnace ready to be spotted anywhere in your shop . . . a versatile combination of melting speed, accurate control and over-all economy.

Melts 30 pounds of red brass in 22 minutes from cold start—17 pounds of steel in 40 minutes. No carbon contamination. Rapid melting prevents oxidation. Excellent for laboratory melting, precision casting, precious metals, high-temperature work.

Self-tuning, easy to operate. Maintenance limited to annual inspection of two electrodes.

Also built in 3, 6 and 40-kw sizes. Send today for free bulletins.

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AJAX ENGINEERING CORP. • AJAX ELECTRIC FURNACE CORP.

142-S

News Digest

story office building purchased last year as part of a long range expansion program. The new address is at 17th and Parade Sts., Erie, Pa.

A huge new rolling mill, costing approximately $4,500,000 and capable of producing extra-wide tapered sheet and plate for aircraft, will be installed at *Aluminum Co. of America's* Davenport, Iowa works by late 1953. Equipment for the mill will be designed, installed and operated by ALCOA under terms of a lease arrangement with the U. S. Air Force's Air Material Command.

A $32,000,000 expansion program that is expected to take about a year to complete is underway at the S. Philadelphia Works of the *Westinghouse Electric Corp.* The project involves re-occupancy, under lease agreement, of the Navy-owned Merchant Marine plant adjoining the S. Philadelphia Works, extensions to existing buildings, extensive purchases of new machine tools, and a previously announced $6,000,000 steam and gas-turbine research and development laboratory.

According to a recent announcement, *The Burpee Can Sealer Co.* has purchased the *E-Z Way Tool Co.*, Chicago, and has transferred all manufacturing operations for the E-Z Way electric hack saw to the Burpee plant.

The 150th anniversary of the *E. I. du Pont de Nemours & Co., Inc.*, was recently observed in ceremonies at the site of the company's first mill on Brandywine Creek. An audience of nearly 7,000 people attended the festivities.

After 62 years at its present address, *William S. Doig Co.* will move its entire plant from 54 Franklin St., Brooklyn, to its new factory on Maple Ave., Haverstraw, N. Y. The general offices will remain at 894 Manhattan Ave., Brooklyn.

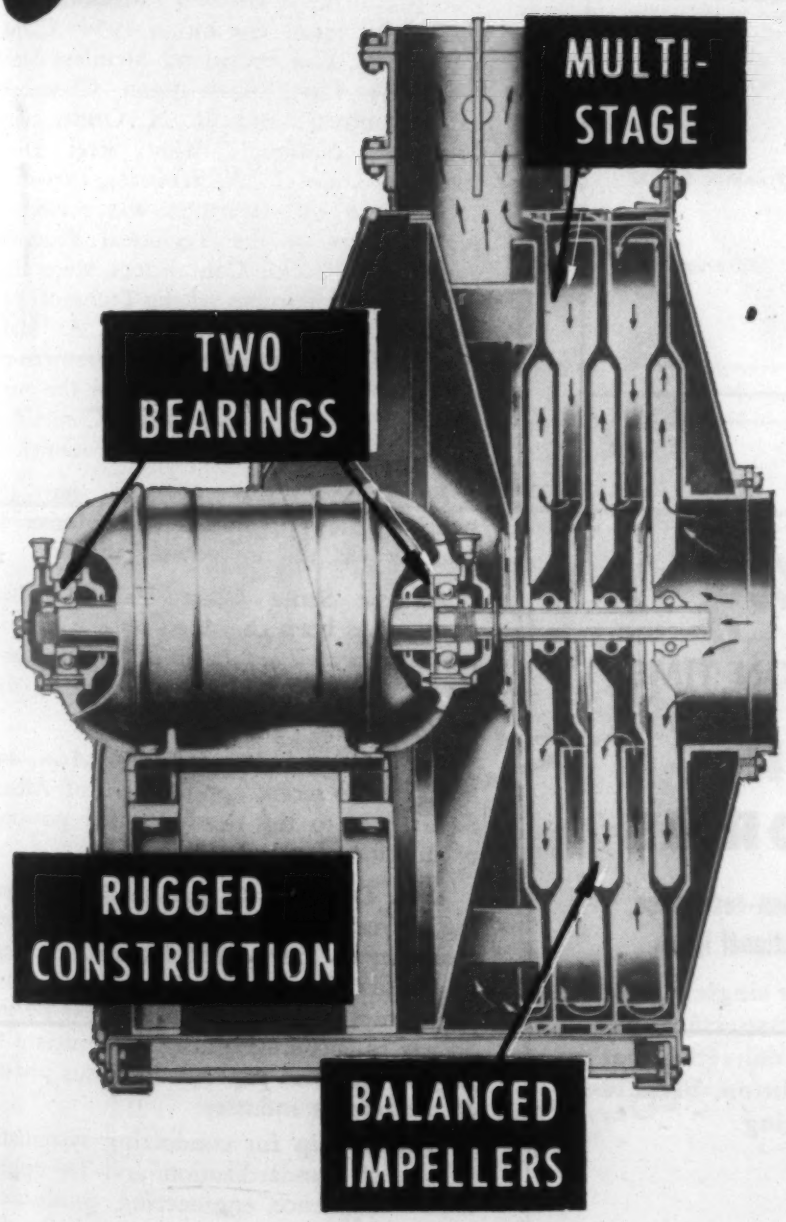
Air Reduction Co. recently held open house at its plant in Acton, Mass. Local civic and business leaders attended at Airco's invitation to inspect the recently completed expansion of its facilities.

Amperex Electronic Corp. has announced that its newly constructed Hicksville, N. Y., plant is now in full operation. The modern structure houses executive and clerical departments and contains elaborate research, engineering and production facilities for the design and manufacture of electronic tubes, transmitting tubes, special purpose tubes, etc.

To encourage training in chemical research and to assist promising young scientists, 13 U. S. educational institutions have been offered 14 fellowships by *Eastman Kodak Co.* for the year 1952-53. All for advanced study, nine of the fellowships are in chemistry, two in chemical engineering, and three in physics. *Tennessee Eastman Co.*, a division of

CONTINUOUS PRODUCTION *Assured 4 Ways*

WITH SPENCER TURBO-COMPRESSORS



There are good reasons why the annual installation of Spencer Turbos has increased tenfold in ten years and why a recent analysis shows that repair parts amount to less than one dollar per machine per year.

No. 1. The Spencer multi-stage construction allows a smaller diameter machine with lower peripheral speeds of the fan blades and of the motor itself. The wear on the bearings is therefore cut to a minimum.

No. 2. The only rotating contacts are at the two ball bearings, which if kept greased will assure satisfactory operation without work stoppages for many years.

No. 3. Here is a machine as simple as an electric fan, with a rugged construction, as sturdy as a steel bridge and with wide clearances between the rotating elements and stationary parts. Users say "the Spencer goes on forever with little attention."

No. 4. Balanced Impellers. Each fan is individually balanced before the machine is assembled. This decreases the vibration, increases the life of the bearings and packing and produces quiet performance.

35 TO 20,000 C.F.M.; 4 OZ. TO 10 LBS.; 1/3 TO 1,000 H.P. 440-H

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Custom Extrusion and Extrusion Fabrication Service being used profitably for an increasing number of industrial and other applications

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For Soldering with flame, carbon-resistance, oven, induction and conventional iron.

DIMENSIONAL STABILITY Every single Kester Solderform is made exactly to specification. What's more . . . they are delivered that way to you, in perfect condition, because of Kester's scientific packaging.

Write for sample assortment or test samples for your specific job.

KESTER SOLDER COMPANY
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KESTER SOLDER

News Digest

Kodak, has offered five additional fellowships to five educational institutions in the southeastern states.

News of Societies

At their 12th annual convention recently held in Hot Springs, Va., members of the *Alloy Casting Institute* elected the following officers to serve for the coming year: Harvey T. Harrison, executive vice president, Duraloy Co., was reelected as president; G. A. Baker, vice president, The Duriron Co., was elected as the new vice president. Two new directors were elected for terms ending in 1954: C. M. Carmichael, vice president, Stainless Steel & Alloys Div., Shawinigan Chemicals Ltd., Montreal; and M. N. Ornitz, vice president, National Alloy Steel Div., Blaw-Knox Co. E. A. Schoefer, exceutive secretary of the Institute, was reelected. New officers of the Technical Research and Shop Practice Committees were also announced: chairman of the Technical Research Committee is now N. A. Matthews, of the metallurgical Laboratories of American Brake Shoe Co.; and the new chairman of the shop Practice Committee is R. O'Conner, Cooper Alloy Foundry.

Porcelain Enamel Institute has announced the appointment of Homer J. Humbert as administrative assistant.

A new Santa Clara Valley, Calif., chapter has been chartered by the *American Society of Tool Engineers*. The chapter is the 98th to be chartered by the 22,000-member technical society.

The National Metal Trades Assn. announced the recent appointment of Albert S. Gardner to the newly-created position of director of member relations.

J. H. DuBois, vice president, engineering, Mycalex Corp., has been appointed chairman of the annual National *Society of Plastics Engineers* Prize Paper Contest. The contest is sponsored each year by the Society to encourage plastics technicians to prepare technical papers on various phases of the plastics industry.

A fellowship for conducting systematic studies of standardization and its applications in science, engineering, production and marketing has been announced by the *Mellon Institute*. This fellowship will be sustained at the Institute by a grant from the *Sarah Mellon Scaife Foundation* of Pittsburgh, and its projects will be organized and supervised by Dr. Dickson Reck, Advisory Fellow.

Dr. Hilding V. Tornebohm, vice president and technical director of SKF Industries, Goteborg, Sweden, has been elected president of the *International Organization for Standardization*.

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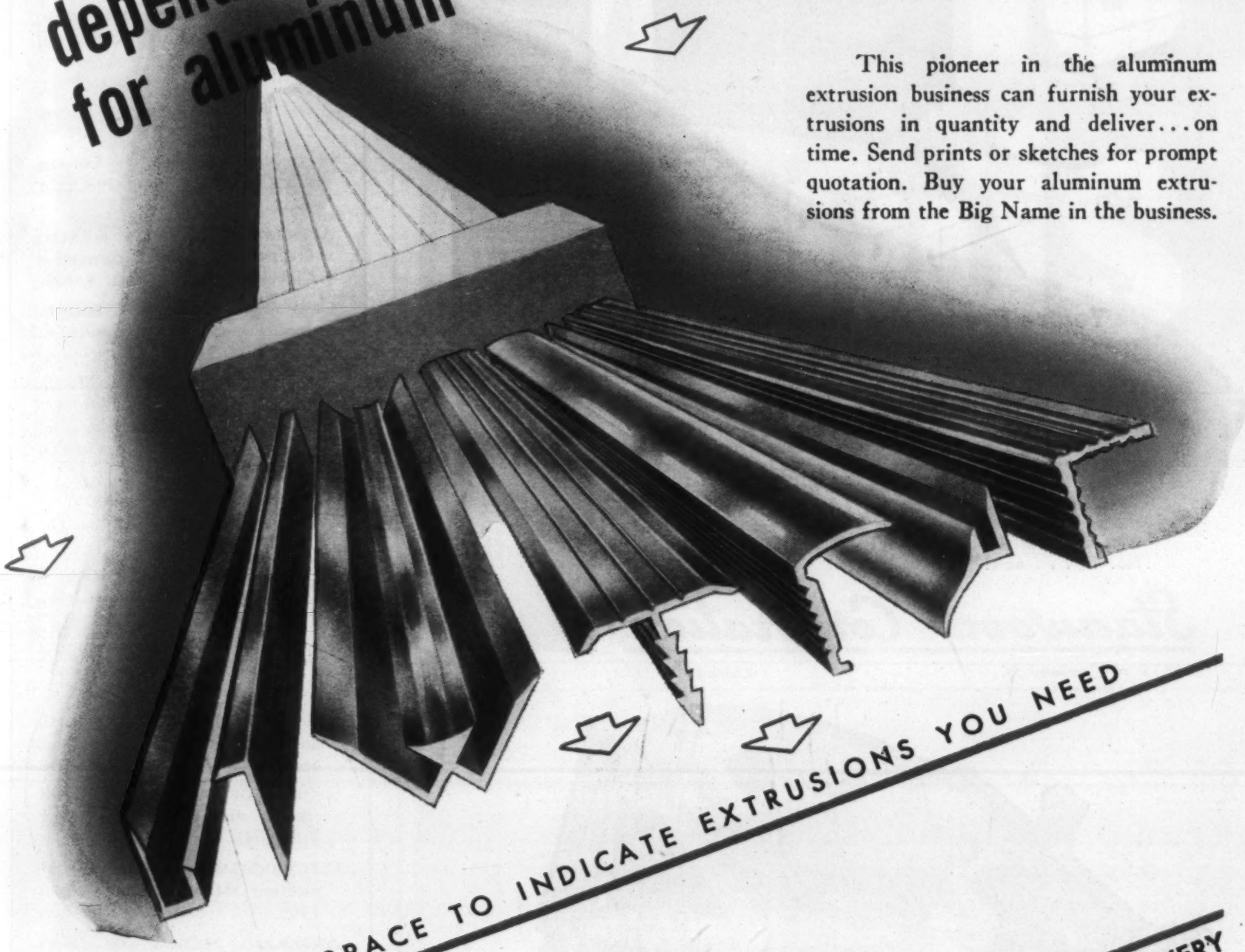

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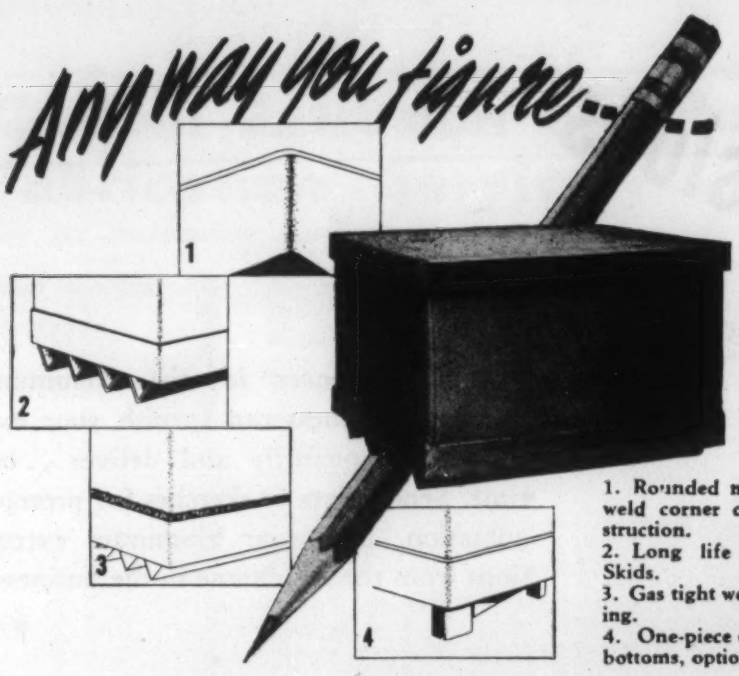

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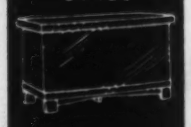

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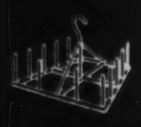
FIXTURES



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Meetings and Expositions

PRESSED METAL INSTITUTE, annual meeting. Pocono Manor, Pa. Sept. 14-18, 1952.

NATIONAL FOUNDRY ASSOCIATION, annual meeting. Chicago. Sept. 18-19, 1952.

STEEL FOUNDERS' SOCIETY, fall meeting. Hot Springs, Va. Sept. 22-23, 1952.

NATIONAL ELECTRONICS CONFERENCE. Chicago. Sept. 29-Oct. 1, 1952.

ASSOCIATION OF IRON & STEEL ENGINEERS, annual convention. Cleveland. Sept. 30-Oct. 3, 1952.

GRAY IRON FOUNDERS' SOCIETY, annual meeting. Cleveland. Oct. 16-17, 1952.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Institute of Metals Div. fall meeting. Philadelphia. Oct. 20-22, 1952.

AMERICAN WELDING SOCIETY, annual meeting. Philadelphia. Oct. 20-24, 1952.

NATIONAL METAL CONGRESS & EXPOSITION. Philadelphia. Oct. 20-24, 1952.

SOCIETY FOR NON-DESTRUCTIVE TESTING, annual meeting. Philadelphia. Oct. 20-24, 1952.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Oct. 22-24, 1952.

SOCIETY OF AUTOMOTIVE ENGINEERS, transportation meeting. Pittsburgh. Oct. 22-24, 1952.

ELECTROCHEMICAL SOCIETY, fall meeting. Montreal. Oct. 26-30, 1952.

AMERICAN SOCIETY OF BODY ENGINEERS, annual convention. Detroit. Oct. 29-31, 1952.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Fuels and AIME Coal Divs. joint conference. Philadelphia. Oct. 30-31, 1952.

SOCIETY OF AUTOMOTIVE ENGINEERS, diesel engine meeting. St. Louis. Nov. 3-4, 1952.

PITTSBURGH DIFFRACTION CONFERENCE. Pittsburgh. Nov. 6-7, 1952.

SOCIETY OF AUTOMOTIVE ENGINEERS, fuels and lubricants meeting. Tulsa. Nov. 6-7, 1952.

NATIONAL FOUNDRY ASSOCIATION, annual meeting. Chicago. Nov. 10-12, 1952.

AMERICAN STANDARDS ASSOCIATION, annual meeting. New York. Nov. 19, 1952.

AMERICAN SOCIETY FOR QUALITY CONTROL, Mid-West conference. Indianapolis Nov. 20-21, 1952.